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CALIFORNIA FISH AND GAME

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VOLUME 50 JULY 1964 NUMBER 3

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A DEER STUDY IN A REDWOOD-DOUGLAS FIR FOREST TYPE[1]

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INTRODUCTION

A large part of the north coastal region of California consists of redwood-Douglas fir forests. Inhabiting this region are substantial numbers of Columbian black-tailed deer *(Odocoileus hemionus columbianus)*. To understand the problems and the role of the deer in the management of these forests, a study was initiated in the summer of 1959.

Most of these forests are owned and developed by industrial timber companies and the timberlands are managed on a sustained yield basis. In much of Mendocino County, the trees are harvested by a selective cutting technique which preserves the forest canopy, but in areas where heavy logging has left bare, opened areas, reforestation by extensive seedling planting programs is practiced. Douglas-fir, and more recently, Monterey pine, are the timber species planted. The black-tailed deer populations are profoundly affected by these forest management practices, and in turn exert an influence on both the natural and artificial forest reproduction.

No detailed study has been made previously on the deer inhabiting the coastal redwood-fir forests of California. Very little knowledge was available concerning their food habits, reproduction, seasonal condition, diseases or parasites, or of the relationship that exists between the deer and the reproduction of the principal timber-producing trees. Therefore, to gather some of this information a cooperative, two-phase study was conducted on the lands of the Rockport Redwood Company in Mendocino County. One phase, handled by the Department's Region III unit wildlife manager, evaluated the direct effect of deer browsing upon the trees' growth by constructing deer-proof exclosures and making periodic observations. The other phase, carried out by making a special deer collection by the personnel of the Department's Wildlife Investigations Laboratory, determined the seasonal food habits of the deer as well as the actual extent of utilization and periods of use on the trees concerned. Other biological information was gathered as the opportunity arose.

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DESCRIPTION OF THE AREA

The Rockport Redwood Company property consists of approximately 33,000 acres in the heart of the redwood belt. The collection area lies in the center of the property about 8 miles east and north of the company town of Rockport. It includes most of the area within the property that is drained by South Hollow Tree Creek, which follows a generally north-south direction at an elevation of 1,000-1,200 feet. This terrain is rather precipitous, characterized by alternate canyons and ridges rising to 1,500 feet on the westerly side of the drainage and on the east side to 2,500 feet. The few level locations consist of creek bottom terraces or alluvial flats.

Division of the area into physiographic units depends upon the area's fire and logging history. There are three broad units to be considered: virgin forest, old cutover, and recent cutover. Most of the forest area, which consists of heavy virgin and second growth timber, is on the seaward slope of the mountains and is being harvested under "selective cutting" techniques. Most of the virgin growth was burned off in 1945, and salvable timber cut, in the area lying on the westerly side of the South Hollow Tree Creek drainage, including the tributaries, Little Waldron, Redwood, Bear, and Middle Creeks. The old cutover unit now consists of an interspersion of high brush and a vigorous and healthy association of sapling and pole-class redwood and Douglas-fir timber. The remainder of the collection area, most of which has been cutover as recently as 1953-1956, consists of an interspersion of open, bare areas, low brush, and timber reproduction.

DESCRIPTION OF THE VEGETATION

Generally the vegetation of the collection area is characterized by the flora representative of the plant communities Munz (1959) calls "redwood and Douglas-fir forests." This includes coast redwod, Douglas-fir, tanbark oak, madrone, with an understory of wax myrtle, chinquapin, rhododendron, huckleberry, salal, wood sorrel, redwood-ivy, sword fern, and western whipplea (*see* Appendix I for scientific names). On the Rockport area, several other plants commonly grow in this redwood-Douglas fir association. Coast whitethorn, tobacco brush, canyon live-oak, western raspberry, chaparral broom (coyote brush), gooseberry, California honeysuckle, blackberry, and several species of manzanita are all common shrubs in the collection area. On all three of the general physiographic units described, the species composition is very much the same; only the percentage of composition varies from unit to unit.

The virgin forest area is vegetated with most of the representative trees and shrubs of the typical redwood and Douglas-fir community, with trees predominant. Because of the influence of the 1945 fire on the old cutover area, dense and rather extensive stands of fire-encouraged tobacco brush are found throughout this area. However, redwood and Douglas-fir trees are making a vigorous, healthy and successful escape through the brush and are co-dominants over most of this area. Cutover areas, clean logged relatively recently, are vegetated principally by brush species, often dominated by coast whitethorn and/or huckleberry, with madrone and tanbark oak competing successfully through-

TABLE 2

Conifer Growth by Tree Type on the Rockport Plots

	1959				1963					
	Unprotected		Protected		Unprotected			Protected		
Tree Type	Average height	Number trees	Average height	Number trees	Average height	Number trees	Percent gain	Average height	Number trees	Percent gain
Planted Douglas-fir	8.2	91	8.8	68	16.8	68	105	40.3	53	358
Natural Douglas-fir	8.3	24	8.4	30	16.4	23	97	51.3	27	511
Natural Redwood	4.0	87	4.6	28	17.4	77	335	26.7	25	480

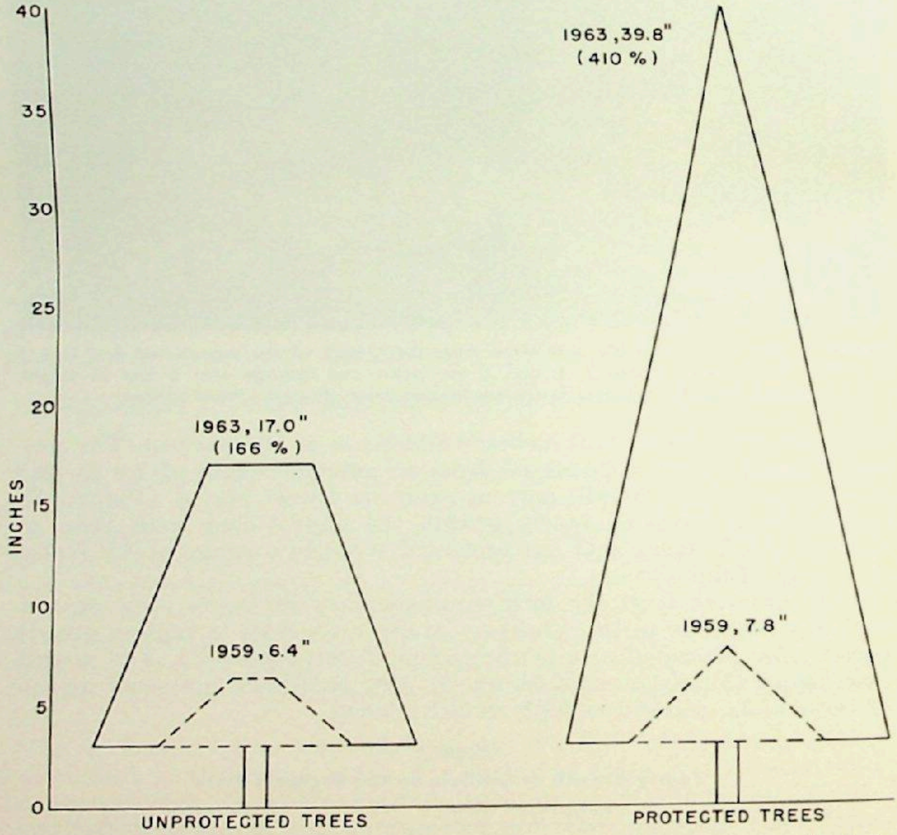

FIGURE 2. Average height increase in four growing seasons of young conifers on the Rockport study areas.

A breakdown of the data to species and type of tree on the exclosure plots on the Rockport area shows different rates of growth (Table 2). Of the unprotected trees, redwood showed the largest rate of growth; over three times as great as that of the Douglas-fir. Protected, the redwood and Douglas-fir trees, naturally-produced from seed and estimated as 6 to 8 years old, grew at a faster rate than did the protected Douglas-fir seedlings planted in 1959.

The dominant shrub in the Rockport exclosures was tobacco brush. Within the fence this shrub grew to a height of 8 to 10 feet (Figure 1). Outside of the fenced plots many of the tobacco brush plants were browsed almost to the ground (Figure 4). Other brush species such as canyon live oak, coyote bush, and *Ceanothus* species showed the same kind of heavy use.

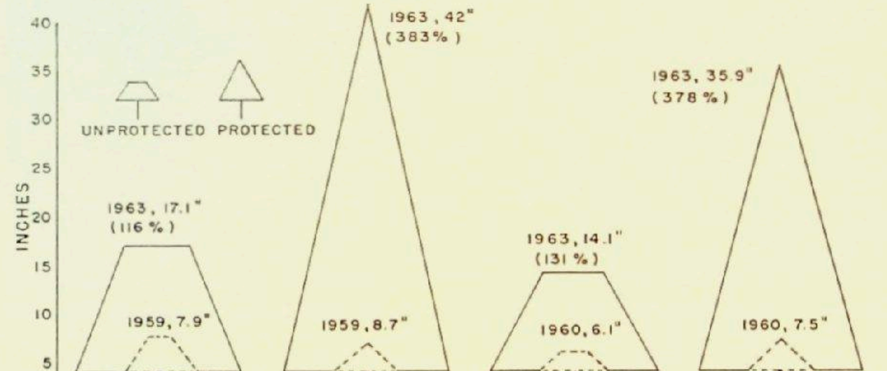

FIGURE 3. Average heights and growth increase of trees on exclosure plots adjacent to the Rockport study area. (a) Jackson State Forest, Douglas-fir planted January, 1959; (b) Union Lumber Company, Douglas-fir planted January, 1960; (c) Union Lumber Company, Douglas-fir and Monterey pine planted January, 1960; (d) Union Lumber Company, Douglas-fir and Monterey pine planted December, 1954.

out these areas. The conifers are far less successful in these open areas, and in these locations attempts at reforestation are being made by the company.

Within the broad physiographic units outlined, most of the vegetation already discussed is found on the hillsides and ridges. There are three physiographic sub-units that need separate consideration. These are the creek bottoms, terraces or flats, and the logging roads and skid-roads that cross-hatch the property. Vegetation in the shaded draws and creek bottoms generally includes several species of willow, alder, maple, Oregon ash, California bay, thimbleberry, ferns, horsetail, sedges, and a variety of shade-loving forbs. The roadsides and flats are vegetated with unique associations of plants which show a seasonal variation both in abundance and species composition. Bolander's phacelia, horsetail, thistle, lupine, Australian fireweed, western starflower, trefoils, cudweeds, tarweed, mullein, hawkweed, and penstemon are some of the more common forbs growing along the skid-roadsides and banks. Horsetail and phacelia are present throughout the year until the first frosts. Starflower has a cosmopolitan distribution on exposed soil over the entire area. Wild strawberry, sweet pea, blackberry, or whipplea often cover the road banks.

Most of the grass is on the flats and creek bottom terraces. Sedges and bracken are interspersed with the grasses on moist terraces. Seasonally, other common plants on the flats are tarweed, cudweed, thistle, and collomia. Brush seedlings of coast whitethorn, chaparral broom, madrone, and others were common on the flats. Many of the flats are planted with Douglas-fir and Monterey pine seedings.

EVALUATION OF DEER BROWSING UPON CONIFER REPRODUCTION

Methods

In the summer of 1959, two deerproof exclosures were constructed on the study area within the Rockport Redwood Company property. The exclosures were an overhanging type suggested by the work of Jones and Longhurst (1958). They were constructed on two creek terraces representing typical areas under a reforestation program.

In the fall of 1959, 202 trees subjected to deer browsing outside of the exclosures, and 126 trees fully protected were tagged and measured. These trees were a mixture of Douglas-fir and redwood, naturally reproduced from seed, and seedlings of Douglas-fir planted in February 1959.

The exclosure plots were checked in the fall, after the growing period, each of the next 4 years. The surviving trees were measured to the nearest inch, from the ground level to the terminal tip. In the final 1963 field check, 168 unprotected and 105 protected trees were measured.

To obtain corroborative data, four other exclosures were constructed and checked. Three of these were on the adjacent Union Lumber Company property and the other in the nearby Jackson State Forest.

Results

From 1959 through 1963, conifers protected by the deerproof exclosures made over three times the growth of those trees outside of the exclosures (Figure 1). Unprotected, the average height of the trees

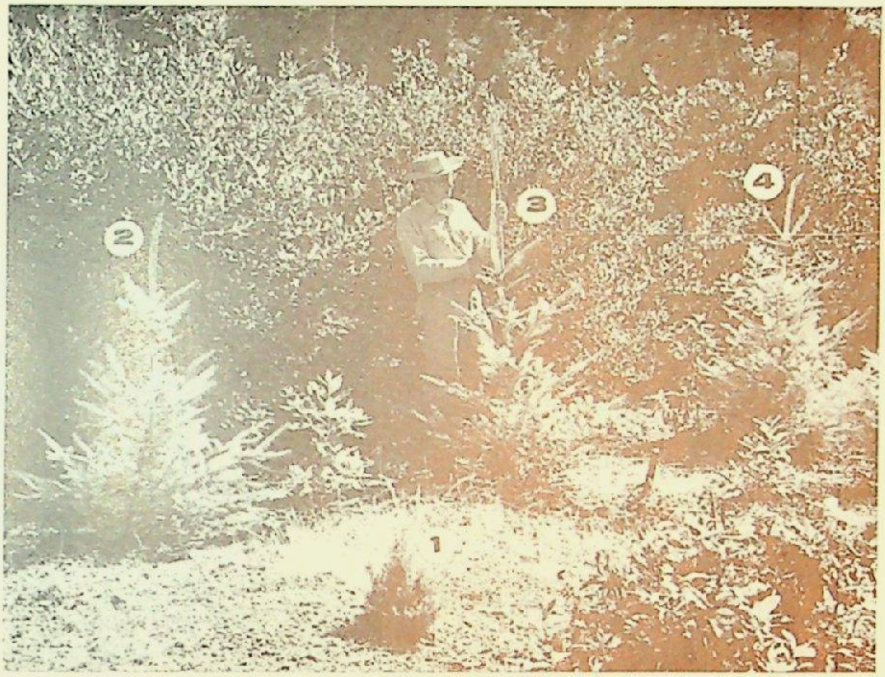

FIGURE 1. Protected firs made over three times the growth of the unprotected firs. Tree 1 is outside the exclosure. Trees 2, 3, and 4 are inside and average over 5 feet in height. The tall shrubs in the exclosure are tobacco brush. *Photo by Ward Gillilan.*

increased from 6.4 to 17.0 inches, an increase of 166 percent. The protected trees, however, increased from an average height of 7.8 to 39.8 inches, an increase of 410 percent over the 4-year period (Figure 2). Expressed in terms of yearly growth the unprotected trees grew an average of 2.7 inches and the protected trees an average of 8.0 inches each year (Table 1).

Data collected from the four supplementary exclosure plots on timberlands adjacent to the Rockport study area show a similar growth pattern for protected and nonprotected trees (Figure 3). The growth increase of Douglas-fir and Monterey pine seedlings, protected on one of these plots, reached as high as 601 percent.

TABLE 1

Yearly Growth of Conifers on the Rockport Plots

	Unprotected trees			*Protected trees*		
Year	*Average height in inches*	*Growth in inches*	*Number of trees*	*Average height in inches*	*Growth in inches*	*Number of trees*
1959	6.4	–	202	7.8	–	126
1960	8.1	1.7	174	12.6	4.8	107
1961	10.1	2.0	171	21.5	8.9	105
1962	13.3	3.2	168	28.5	7.0	105
1963	17.0	3.7	168	39.8	11.3	105
Average yearly growth		2.7			8.0	

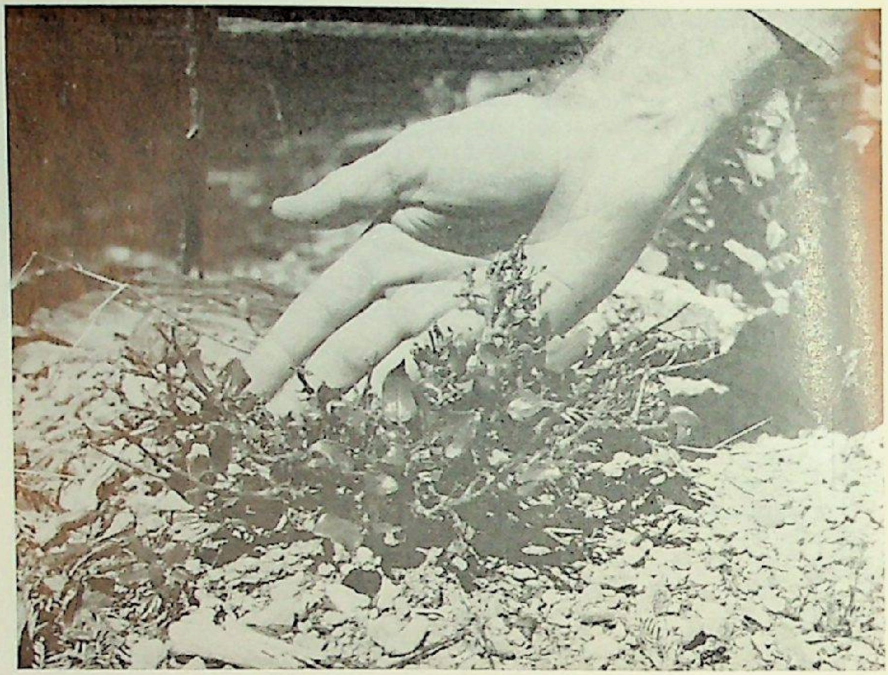

FIGURE 4. Tobacco brush outside the exclosures was browsed to the ground level. Inside the fence the brush grew to 8 to 10 feet in height. *Photo by Ward Gillilan.*

FOOD HABITS

Collection

Thirty-two rumen samples were obtained from cooperating sportsmen during the regular August-September 1961 hunting season. A special collection of 50 deer began in November 1961 with 10 deer to be taken in alternate months. This was not a rigid schedule however, and some changes were made as occasion demanded. In 1961, 10 deer were taken in November and 10 in December; in 1962, 11 were taken in March, 6 in April, 7 in June, and 6 in July. All animals were taken by shooting. Primarily adult females were shot in order to obtain reproduction data. Toward the end of the collection, when reproductive data were no longer obtainable, a number of younger deer were collected.

In an effort to describe more accurately the spring utilization of Douglas-fir, an additional 10 deer were taken each month during April, May, and June, 1963. The exact collection dates were regulated as closely as possible to the beginning, peak, and ebb of the growing period of the major food plants involved.

In addition to collecting the rumen contents for food analysis, data on reproduction, age, condition, and parasites were gathered as the animals were processed.

1961-1962 Results

The rumen contents of 112 deer were examined for food at the Department of Fish and Game Field Station in Sacramento. The results indicate a definite seasonal trend in feeding habits.

Browse contributed 62 percent of the food of the deer collected during the August-September hunting season. Of the browse, coast whitethorn, California huckleberry and madrone were the most important. Oak mast made up five percent of the browse. Forbs made up 30 percent, and the remaining 8 percent of the food was grass and horsetail.

Fall rains brought on the growth of new grass which influenced the diet of deer collected in November and December. Grass comprised almost 30 percent of the November food, and 50 percent in December.

During the same period the acorn crop matured. Tanbark oak and canyon live-oak leafage and acorns made up 25 percent of the November diet and over 40 percent in December.

Frost killed most of the forbs and these were little utilized.

Grass made up one-third of the food selected in March and April. Horsetail contributed 13 and 4 percent of the food in those months.

Forbs made virtually no contribution to the March diet, but in April phacelia and starflower were taken, together making over 20 percent of the food.

The browses begin spring growth in March and April. Coincident with this was an increase of browse in the diet. Leaf buds, young stems, leafage, and flower heads of such species as tobacco brush, madrone, whipplea, salal, chaparral broom, and Douglas-fir were taken in large amounts.

In June and July, grasses began to dry and mature. Their use was 15.7 percent and 0.3 percent of the June and July diets. Utilization of horsetail followed the same pattern, 18.6 and 0.3 percent for those months.

More forbs were available and starflower, redwood-ivy, trefoil and Australian fireweed together made up 20 percent of the June food and over one-third of the July diet.

As the use of grass slacked off, more browse was consumed, 45 percent in June and 60 percent in July.

Douglas-fir needles occurred in one-fourth of the stomachs collected. In March, they occurred in 4 out of 10 stomachs making up one percent of the food in two stomachs and two percent in another. Fir buds occurred in all six stomachs collected in April, making up one percent of the food in two stomachs, 10 percent in another, and 70 percent in a fourth, with trace amounts in the remaining two. The presence of green and dry needles in the stomachs throughout the rest of the year shows some incidental use those months; but the presence of complete leaf buds in the rumens sampled during March and April shows a definite selection of this part of the plant as a food item (Figure 5).

1963 Results

Young madrone leaf-buds and green grass stems and leafage each contributed about one-third of the food eaten in April. New stems and fertile cones of horsetail contributed another 15 percent. The green needles and bud tips of coast redwood and Douglas-fir were 4.8 and

1.1 percent of the April food. Green forb leafage and stems constituted 2.5 percent. The collection was made during the first week of April, when the growth buds of some of the principal trees and shrubs were beginning to sprout.

By the third week of May, the spring growth period was near its peak. Douglas-fir and redwood sprouting tips were 20.6 and 0.3 percent, respectively, of the food found in the nine deer stomachs analyzed for May. Young madrone leaf-buds still were over one-third (37.1 percent) of the May diet, grass dropping to about seven percent and horsetail to eight percent. Green forbs increased to 16 percent.

The last collection was made the third week in June after the peak of the growth activity of the principal trees. Redwood needles still made 1.5 percent of the food, but Douglas-fir needles were absent from the June stomachs. Young leafage of madrone was almost 44 percent of the June food. Grass virtually disappeared from the diet. Horsetail was 17 percent, and forbs increased to 25 percent of the June food.

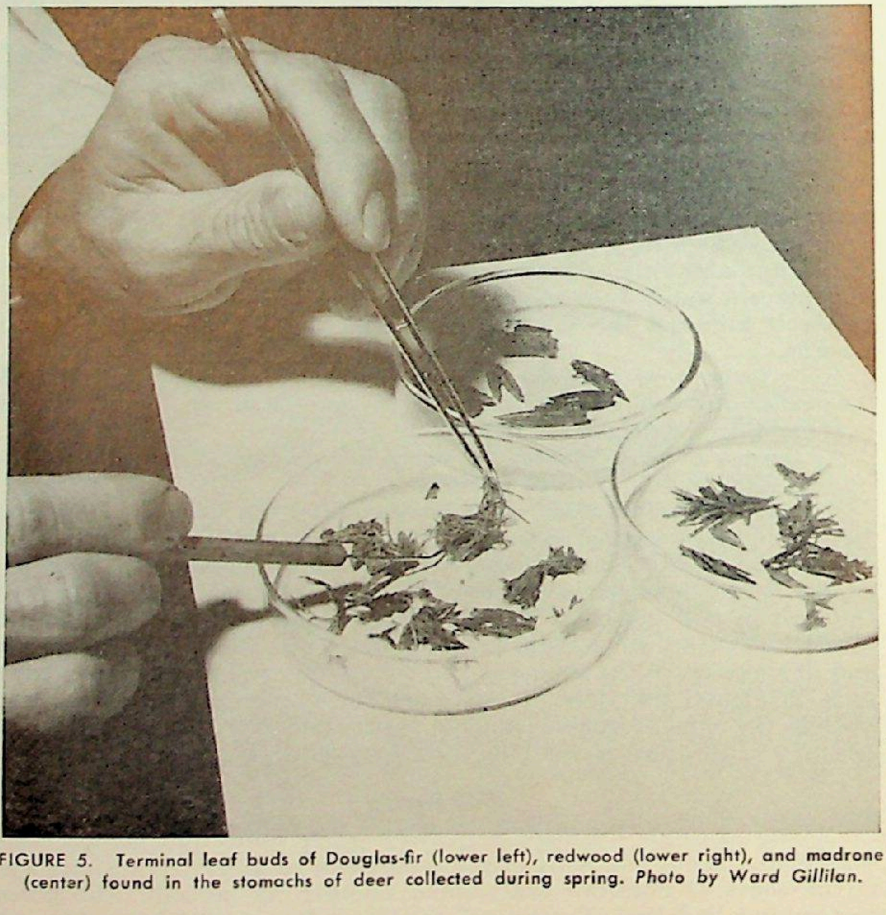

FIGURE 5. Terminal leaf buds of Douglas-fir (lower left), redwood (lower right), and madrone (center) found in the stomachs of deer collected during spring. *Photo by Ward Gillilan.*

MISCELLANEOUS DATA

Weights and Condition

All animals were weighed to the nearest pound on a spring scale. The average live weight of adult females was 81.6 pounds and the dressed weight, 43.8 pounds (Table 3).

TABLE 3

Average Weights in Pounds of Adult Female Black-tailed Deer from Rockport

Number of Deer	*Month*	*Live weight*	*Dressed weight*	*Dressed weight percent*
8	November, 1961	77.5	43.8	56.5
8	December, 1961	81.0	45.2	55.8
8	March, 1962	79.0	43.2	54.7
2	April, 1962	109.0	56.0	51.4
3	June, 1962	88.6	45.3	51.1
4	July, 1962	92.0	45.5	49.5
9	April, 1963	87.6	41.3	47.1
3	May, 1963	91.3	44.0	48.2
6	June, 1963	83.2	39.8	47.8
51		81.6	43.8	53.6

The general condition of all the collected deer was good. Some increase of fat was noted during December coincident with the heavy use of acorn mast, but as the collection progressed, no significant changes in deer condition were observed. This was true for all age groups examined and probably indicates that the quantity and quality of food is relatively stable throughout the year.

The average weight and condition of the deer examined during the spring of 1963 was essentially the same as during the previous spring.

No other data are available on weights of black-tailed deer from similar California habitats. However, the Rockport females were about the same size as black-tailed deer taken at Cow Mountain in the inner-coastal mountains, and smaller than those taken from other inland ranges of California (Table 4).

TABLE 4

Average Live Weights of Adult Female Black-tailed Deer from California

Location	*Pounds*
Rockport Redwood Company, Mendocino County	81.6
Tehama Winter Range, Tehama County	102.3
Elephant Hill, Butte County	90.7
Lake Hollow, Tehama County	85.7
Cow Mountain, Lake County	82.0
San Benito County	91.1

Reproduction

Embryo counts were taken from each pregnant doe collected. Eighteen does collected in 1961-62 carried 24 embryos giving a ratio of 133 embryos per 100 adult does. Two of four yearling females were pregnant, each carrying a single embryo. There was 95 percent pregnancy in the adult does. One 7-year adult female had no embryos, but the presence of *corpora lutea* in the ovaries indicated she had been bred.

Sex ratio of the embryos was 133 males to 100 females. Ovulation rate was 155 ova per 100 adult does. Eighty-six percent of the ova produced were fertilized. Fifty-nine percent of the does carried single embryos and 41 percent carried twins. There were no triplets.

All nine adult does collected in 1963 contained twin embryos.

Breeding dates

Ages were determined for individual embryos and conception dates established for 18 deer in 1961-62 and nine in 1963. The earliest successful breeding occurred the last week of October. The peak period of breeding was the first two weeks of November when about 50 percent of the does were bred. Breeding continued into December with the last recorded pregnancy December 20.

A comparison with data from five inland black-tailed deer herds showed the Rockport deer were the earliest breeders (Table 5).

Embryo ages were determined by the method of Hudson and Browman, (1959).

TABLE 5

Peak Breeding Dates in Some California Black-tailed Deer Herds

Location	*Dates*
Rockport, Mendocino County	First two weeks of November
Oak Knoll, Siskiyou County	Second two weeks of December
Tehama Winter Range, Tehama County	Last week of December
Lake Hollow, Tehama County	Third and fourth week of December
Elephant Hill, Butte County	Third and fourth week of November
Cow Mountain, Lake County	Second and third week of November

Diseases and Parasites

Blood samples were taken from the 80 deer collected. Agglutination tests were run for leptospirosis and brucellosis with negative results.

Autopsies revealed no evidence of infectious disease of bacterial or viral origin.

Being parasitized is essentially a normal condition for wild deer, so only when these parasites reach high levels is this condition abnormal. The 80 deer examined, with few exceptions, carried light parasite loads. A complete list of parasites identified in this study is given in Table 6.

Ectoparasites such as fleas, ticks, lice, and keds were present throughout the collection periods and showed the normal seasonal increase and decline.

TABLE 6

Parasites Found in Rockport Deer

Common name	*Scientific name*	*Common name*	*Scientific name*
Lung worms	*Dictyocaulus filaria*	Eye worm	*Thelazia californiensis*
	Elaphostrongylus odocoilei	Tapeworms	*Cysticercus tenuicollis* *Moniezia* sp.
Stomach worms	*Hemonchus contortus*	Nose bot	*Cephenemyia* sp.
	Ostertagia trifurcata	Fleas	*Pulex irritans*
	Ostertagia circumcincta	Ticks	*Dermacentor occidentalis*
	Nematodirus sp.		*Ixodes pacificus*
	Trichostrongylus sp.	Deer Ked	*Lipoptena depressa*
Liver fluke	*Fasciola hepatica*	Lice	*Trichodectes tibialis*
Body worm	*Setaria cervi*		

Important endoparasites encountered were lung worms, stomach worms, and a liver fluke. Liver flukes were collected from only one animal, but other deer showed evidence of past fluke infestations.

DISCUSSION

Black-tailed deer exert a considerable influence upon areas of coastal redwood-fir forests under intensive reforestation programs. Both phases of the Rockport study showed the adverse effect of the deer on the young timber-producing trees, both planted and naturally-produced

To escape browsing damage by deer, a young conifer must reach a height of 3 to 4 feet. Field observations show that deer generally take the lateral tips from a tree of this height, leaving the terminal tip to continue its growth. When all of the top shoots are browsed off the result is a shrubby, deformed tree.

On the Rockport study plots the young Douglas-firs protected by deerproof exclosures reached the "escape" height in a 4-year period. At the annual average growth of 2.7 inches (Table 1), the unprotected planted Douglas-fir seedlings would have taken over 13 years to escape. At the same rate the unprotected firs, produced naturally, would have taken almost 20 years to grow beyond the reach of the deer. These figures are based on averages from all the trees measured. Seriously damaged trees may show even slower progress. Such trees grew less than 4 inches in a 10-year period in a western Washington study (Brown, 1961).

The results of the special spring collection show that the coincidence of Dougas-fir and redwood use with the spring growing period is very strict. Athough trace amounts occurred in the stomachs sampled each month, the peak of fir utilization came in March, April, and May. There was no occurrence in June.

Redwood followed the same pattern of use, but made an appreciably smaller volume of the deer food. Unprotected redwood trees made three times as much growth as did the fir trees. Therefore, redwood either is better able to withstand the rigors of deer browsing or is less acceptable to the deer as a food item.

While it appears that vegetation is lush in the wet, foggy coastal redwood-fir forests, actually the quality of food may be low. Shading in the mature forests reduces the forage quality of the understory food plants, and because of the excellent growing conditions in this coastal zone, plant succession following logging operations generally proceeds rapidly (Taber, 1961). This results in mature stands of brush, out of reach of the deer. Hence the deer forage in the opened areas. Field observations revealed that virtually 100 percent of the food plants within reach showed some deer use. Cowan (1945) has reported that browsing on Douglas-fir in "inferior forest types" in British Columbia has approached 100 percent.

Depending on general weather conditions, a yearly seasonal-food-habits pattern similar to that of the 1961-62 collection period can be expected in the California coastal redwood-fir forest types. Grass, horsetail, oak mast, madrone, coast whitethorn, California huckleberry, and tobacco brush appear to be significant food plants in the ecology of the Rockport deer. Grass was found in over 75 percent of the stomachs. Grass together with certain of the browse seedlings and forbs like cudweed, trefoil, and ferns are common on the flats and terraces. These food items indicate the importance of these areas to deer, especially during the fall and spring.

The cool, wet spring in 1963 caused a later but better vegetative growing period. All of the woody plants put on an exceptional growth during that season. As a result, the periodicity of Douglas-fir tip use, while coinciding with the peak of spring growth activity, was a month later in 1963 than in 1962. At the same time the percentages of fir found in the stomachs were higher. Madrone use also showed a significant increase. Grass percentages dropped off more dramatically in the spring of 1963 indicating the unusual abundance of new growth on the woody plants. Forb use was about the same for both years.

It should be emphasized here that many of the more significant browse plants are utilized in stages of new growth, regrowth, and in fruit or flower. This is indicated by certain of the food items. Huckleberry, manzanita, and salal fruits and flowers were consumed. Plants such as madrone, canyon live-oak, and chaparral broom, when heavily hedged or browsed, exhibit a regrowth of leaves which characteristically is different in form than the leaves of seedlings or mature plants. It is the newly regrown leaves which were found in high percentages in the deer stomachs. The new spring leaf buds and sprouts also were taken readily.

The analyses of an additional nine stomachs collected during the 1962 hunting season compared favorably with the contents of the 32 stomachs from the 1961 hunting season sample. Individual food items varied, but the proportions of browse for 1961 and 1962 were: browse —62.4 and 61.3 percent, forbs—29.5 and 32.0 percent, grass and horsetail—8.1 and 6.7 percent.

Prior to and during the study the Rockport area was under a bucks-only (forked horn or better) hunting season situation. As a result, deer numbers were not subjected to any effective population control. The study indicates that deer of both sexes must be taken, under a management program, in areas where redwood-Douglas fir timberlands are being intensively reforested. Such a control program also would lend itself to the multiple-use concept of forest management.

ACKNOWLEDGMENTS

Special thanks and recognition must be given to Bernard Z. Agrons, forest manager and supervisor of the Rockport Redwood Company. Mr. Agrons not only generously cooperated by offering the company property as a study area and providing facilities for processing the animals, but also gave generously of his time, interest, enthusiasm, and helpful advice. He also was responsible for initially requesting that the study be made. Company forester L. B. Curtis assisted in constructing the exclosures and gathering field data.

Robert Grundman, Chief Forester for Union Lumber Company, and Gene Sindell, Supervisor for the Jackson State Forest, provided supplemental study areas and personnel to assist in the project.

Mendocino County sportsmen and sportsmen from other parts of the State helped collect stomach samples and other important data during the regular buck season.

Region 3 personnel participating during the course of the study were Robert Lassen and Manley Inlay, who supervised the unit management activities, and Philip Benolkin, Frank Schutz, and Charles Moon who helped construct the exclosures and collect field data. Ward Gillilan took pictures of the exclosures and offered editorial suggestions to the report.

Wildlife Investigation Laboratory personnel who made the special deer collection and autopsied the animals were Eldridge Hunt, Arthur Bischoff, Oscar Brunetti, and Walter Stienecker. Bischoff wrote up the reproductive data; Brunetti the condition, disease, and parasite data; and Stienecker assisted with the food analyses. Carol Ferrel, supervisor of the laboratory activities, offered many helpful suggestions in regard to the study, and assisted in the preparation of the manuscript.

Cliffa M. Corson graciously donated her time and efforts in preparing the graphic representation of the exclosure data.

SUMMARY

A two-phased study was made of the relationship between black-tailed deer, and the reproduction of the principal timber-producing trees in the coastal redwood-Douglas fir forests of California. From 1959 to 1963 two deerproof exclosures were constructed on the property of the Rockport Redwood Company in Mendocino County. A total of 328 trees was tagged and measurements recorded yearly. A total of 121 deer stomachs was analyzed for food items. Forty-one stomachs were collected by hunters during the deer season and 80 obtained by special out-of-season collection. Data on reproduction, age, condition, disease, and parasites were obtained as these animals were processed.

Young conifers outside of the deerproof exclosures averaged 2.7 inches growth per year and made a 166 percent growth increase over the 4-year period. Protected, the trees averaged 8.0 inches per year and made a 410 percent growth increase to an average height of 39.8 inches. On a supplemental plot adjacent to the principal study area the protected trees made a 601 percent growth increase to an average height of 50.5 inches.

Observations show that a young conifer is able to "escape" deer damage at a height of about 3 to 4 feet. Based on the average growths per year, unprotected trees would require as long as 20 years to reach the escape height.

Stomach analyses indicated a definite seasonal pattern in feeding habits. Grass, horsetail, oak mast, madrone, coast whitethorn, California huckleberry, tobacco brush, and Douglas fir are significant food items in the ecology of the Rockport deer. The greatest pressure exerted by the deer upon the conifers comes during a rather limited period in the spring, generally coinciding with the trees' growing period.

The study showed that deer numbers need to be controlled in reforestation areas of the coastal redwood-fir forests of California.

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APPENDIX I

Checklist of Common and Scientific Names

Alder *Alnus tenuifolia*
Australian fireweed *Erechtites prenanthoides*
Bolander's phacelia *Phacelia bolanderi*
Bracken *Pteridium aquilinum*
California bay *Umbellularia californica*
California blackberry *Rubus vitifolius*
California honeysuckle *Lonicera hispidula*
California huckleberry *Vaccinium ovatum*
Canyon live-oak *Quercus chrysolepis*
Chaparral broom *Baccharis pilularis*
Chinquapin *Castanopsis chrysophylla* var. *minor*
Coast redwood *Sequoia sempervirens*
Coast whitethorn *Ceanothus incanus*
Collomia *Collomia heterophylla*
Cudweed *Gnaphalium* sp.
Douglas-fir *Pseudotsuga menziesii*
Gooseberry *Ribes* sp.
Hawkweed *Hieracium* sp.
Horsetail *Equisetum telmateia* var. *braunii*
Lupine *Lupinus* sp.
Madrone *Arbutus menziesii*
Manzanita sp. *Arctostaphylos* sp.
Maple *Acer macrophyllum*
Monterey pine *Pinus radiata*
Mullein *Verbascum thapsus*
Oregon ash *Fraxinus oregona*
Penstemon *Penstemon* sp.
Redwood-ivy *Vancouveria planipetela*
Rhododendron *Rhododendron californicum*
Salal *Gaultheria shallon*
Sedge *Carex* sp.
Sword fern *Polystichum munitum*
Tanbark oak *Lithocarpus densiflora*
Tarweed *Madia exigua*
Thimbleberry *Rubus parviflora*
Thistle *Cirsium vulgare*
Tobacco brush *Ceanothus velutinus* var. *laevigatus*
Trefoil *Lotus* sp.
Wax myrtle *Myrica californica*
Western raspberry *Rubus leucodermis*
Western starflower *Trientalis latifolia*
Western whipplea *Whipplea modesta*
Wild strawberry *Fragaria* sp.
Wild sweet pea *Lathyrus polyphyllus*
Willow *Salix* sp.
Wood sorrel *Oxalis oregana*

MEASUREMENT OF BROWSE GROWTH AND UTILIZATION[1]

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INTRODUCTION

The current annual leader growth on a key forage species is a good indicator of forage production. It not only reflects range conditions that affect the individual plant, but is usually indicative of general conditions that affect the entire range complex. For a given species, the average leader length of a representative sample is valuable for comparing with past years, to determine forage growth trends. Utilization information is useful to the manager in determining proper livestock and wildlife stocking.

The California Department of Fish and Game has used the visual estimate method (Hormay, 1943) for determining browse growth and utilization. This method is applicable to browse plants whose current annual growth can be distinguished from previous growth. It requires making estimations and calculations while in the field.

Frequently, inexperienced men are used for this work, and it is necessary to train them adequately in techniques prior to making a forage check. A half-day training session is held to brief new men on methods and procedures, and to act as a refresher for experienced men. New men are teamed with the experienced in doing the work.

VISUAL ESTIMATE METHOD

The chief objections to the visual estimate system are: (i) it requires a high degree of judgment to come up with sound estimations, (ii) the final results are based on estimation, (iii) leader measurements involve a combination of actual measurement and estimation, (iv) there is no way to recheck calculations made in the field, and (v) it takes time to train a man properly. A breakdown of the steps involved is as follows:

(1) In the fall, after the growing season, the average length of the uncropped current year's leaders is estimated. This is done by measuring a minimum of 20 leaders on at least six terminal whorls around a plant. It may be necessary to check additional leaders before the worker is proficient in estimating.

(2) The average length of the cropped leaders is estimated.

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(3) The difference between the uncropped and the cropped leaders (amount consumed) is divided by the uncropped leader length and multiplied by 100 which gives the percentage use of the cropped leaders.

$$\frac{\text{Uncropped leader} - \text{cropped leader}}{\text{Uncropped leader}} \times 100 = \begin{array}{c}\text{Percent use on}\\ \text{cropped leader}\end{array}$$

(4) The percentage of leaders cropped on a plant is obtained by visual estimation or by getting a sample of cropped to uncropped and calculating the percentage.

$$\frac{\text{Number of cropped leaders}}{\text{Total (uncropped \& cropped) leaders}} \times 100 = \begin{array}{c}\text{Percent of}\\ \text{leaders cropped}\end{array}$$

(5) This latter percentage is multiplied by the percentage of use on the cropped leaders to give the percentage of use for the entire plant.

$$\begin{array}{c}\text{Percent use on}\\ \text{cropped leaders}\end{array} \times \begin{array}{c}\text{Percent of}\\ \text{leaders cropped}\end{array} = \begin{array}{c}\text{Utilization}\\ \text{on plant}\end{array}$$

(6) Steps 2 through 5 are repeated again in the spring to determine the additional use during winter.

In using this system, the field man estimates three components, and by a series of calculations, which are nearly always done in one's head, comes up with a final use figure.

LEADER MEASUREMENT METHOD

In order to eliminate as much of the estimation as possible, and the field calculations, a new system has been employed to make the job strictly mechanical, except for the sampling, which cannot be entirely avoided. Rules on this sampling are:

(1) Each plant to be measured is considered to have four sides, and is divided into quarters from the 5-foot level to the ground. Thirty leaders of the current year's growth, both cropped and uncropped, are randomly selected by whorls and are measured with a hand-held tape. The first whorl selected should be in the top one-fourth of the first side of the plant. The second whorl selected should be on the second side and in the quarter below the top one-fourth of the plant. The selection of whorls to measure should be continued around the plant, sampling each side and covering the plant's other heights. When the number of leaders measured on all four sides does not add up to 30, the procedure should be repeated by starting at the bottom of the first side and working up on each following side.

(2) Only the terminal leaders in the last 1 inch of the whorl should be measured. Laterals and spurs should not be measured.

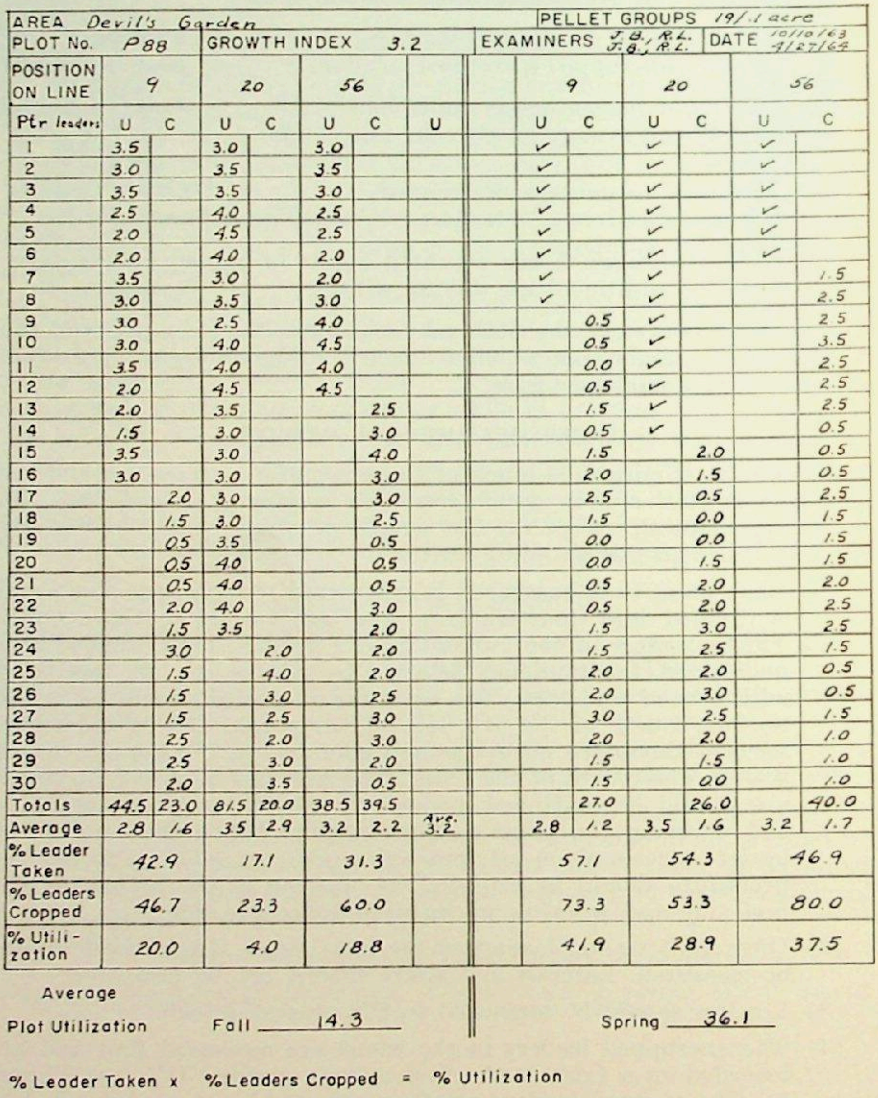
(3) Leaders should be measured to the nearest $\frac{1}{2}$ inch.

(4) The uncropped leaders in the whorl are measured first and are recorded on a form in the first column under "U" (*see* Figure 1). The cropped leaders are then measured and are recorded in

the second column under "C", starting from 30 (bottom of column) and working up. Thus, when 30 cropped and uncropped leaders have been measured the two columns will meet.

(5) If the plant is small, it may not have 30 leaders so all leaders meeting the above requirements should be measured.

(6) Measurements start with current annual growth and extend to the terminal bud. Leaves extending past this point are not measured.



AREA Devil's Garden
PELLET GROUPS 19/.1 acre
PLOT No. P88
GROWTH INDEX 3.2
EXAMINERS J.B., R.L. / J.B., R.L.
DATE 10/10/63 / 4/27/64

POSITION ON LINE	9		20		56				9		20		56	
Ptr leaders	U	C	U	C	U	C	U		U	C	U	C	U	C
1	3.5		3.0		3.0				✓		✓		✓	
2	3.0		3.5		3.5				✓		✓		✓	
3	3.5		3.5		3.0				✓		✓		✓	
4	2.5		4.0		2.5				✓		✓		✓	
5	2.0		4.5		2.5				✓		✓		✓	
6	2.0		4.0		2.0				✓		✓		✓	
7	3.5		3.0		2.0				✓		✓			1.5
8	3.0		3.5		3.0				✓		✓			2.5
9	3.0		2.5		4.0					0.5	✓			2.5
10	3.0		4.0		4.5					0.5	✓			3.5
11	3.5		4.0		4.0					0.0	✓			2.5
12	2.0		4.5		4.5					0.5	✓			2.5
13	2.0		3.5			2.5				1.5	✓			2.5
14	1.5		3.0			3.0				0.5	✓			0.5
15	3.5		3.0			4.0				1.5		2.0		0.5
16	3.0		3.0			3.0				2.0		1.5		0.5
17		2.0	3.0			3.0				2.5		0.5		2.5
18		1.5	3.0			2.5				1.5		0.0		1.5
19		0.5	3.5			0.5				0.0		0.0		1.5
20		0.5	4.0			0.5				0.0		1.5		1.5
21		0.5	4.0			0.5				0.5		2.0		2.0
22		2.0	4.0			3.0				0.5		2.0		2.5
23		1.5	3.5			2.0				1.5		3.0		2.5
24		3.0		2.0		2.0				1.5		2.5		1.5
25		1.5		4.0		2.0				2.0		2.0		0.5
26		1.5		3.0		2.5				2.0		3.0		0.5
27		1.5		2.5		3.0				3.0		2.5		1.5
28		2.5		2.0		3.0				2.0		2.0		1.0
29		2.5		3.0		2.0				1.5		1.5		1.0
30		2.0		3.5		0.5				1.5		0.0		1.0
Totals	44.5	23.0	81.5	20.0	38.5	39.5				27.0		26.0		40.0
Average	2.8	1.6	3.5	2.9	3.2	2.2	Ave. 3.2		2.8	1.2	3.5	1.6	3.2	1.7
% Leader Taken	42.9		17.1		31.3				57.1		54.3		46.9	
% Leaders Cropped	46.7		23.3		60.0				73.3		53.3		80.0	
% Utilization	20.0		4.0		18.8				41.9		28.9		37.5	

Average
Plot Utilization Fall 14.3
Spring 36.1

% Leader Taken x % Leaders Cropped = % Utilization

FIGURE 1. Department of Fish and Game forage utilization survey form.

This ends the field work. All the information is available which is needed for an office worker to calculate utilization.

In the spring, when the plots are rechecked, the same method of sampling is used. It will only be necessary to put a check in the "U" column when an uncropped leader is encountered, since the leader length has already been determined. Only the cropped leaders will have to be measured at this time.

To further simplify the calculations, tables were developed for determining percentages directly from lengths of uncropped and cropped leaders and the ratio of cropped to uncropped leaders.

REFERENCE

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1943. A method for estimating grazing use of bitterbrush. Calif. Forest and Range Exper. Sta., Res. Note 35, 4 pp.

ERYTHROCYTE ANTIGENS OF CALIFORNIA TROUTS[1]

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California Department of Fish and Game
and
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INTRODUCTION

This study was undertaken to find out if immunogenetic techniques could be used to determine relationships and variation in California trouts. Knowledge of these would assist in properly managing California trouts.

Individual variations in erythrocyte antigens have been widely used as genetic markers by a number of workers (Tenth Pacific Science Congress, 1962).

The widespread use of erythrocyte antigens is related to several factors. First, the genetics of antigenic characters are usually uncomplicated. Second, antigenic characters are essentialy independent of environmental influences. Third, these characters can be recognized by relatively simple techniques.

Once suitable antigenic variations have been demonstrated, these can be used to distinguish genetically isolated populations, crosses between different antigenic types within the same population, and to determine the incidence and pattern of interspecific crosses.

The erythrocyte antigens of salmonids have been studied extensively by Ridgway (Tenth Pacific Science Congress, 1962) and others (Cushing and Sprague, 1952; Balakhnin, 1961; Sanders and Wright, 1962; Bingham, 1963). The present investigation developed antisera, and assayed the antigenic diversity of California trouts.

MATERIALS AND METHODS

This study was conducted at the U. S. Fish and Wildlife Service Convict Creek Experiment Station, Mono County, California, and at the University of California, Santa Barbara, from July through November 1962. Trout for the study were supplied by the California Department of Fish and Game. Golden trout, *Salmo aquabonita* (Jordan), were from Laurel Lakes, Mono County; the South Fork of the Kern River and Golden Trout Creek, Tulare County; and Cottonwood Lakes, Inyo County. Rainbow trout, *Salmo gairdnerii* (Richardson), of the fall-spawning strain were from Hot Creek Hatchery broodstock, and those of the spring-spawning strain were from Mt. Whitney Hatchery broodstock. Lahontan cutthroat trout, *Salmo clarkii henshawi* (Richardson), were collected at Heenan Lake, Alpine County. Brown trout, *Salmo trutta* (Linnaeus), were from Mt. Whitney Hatchery broodstock. Eastern brook trout, *Salvelinus fontinalis* (Mitchill), were from Mt. Whitney Hatchery broodstock.

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[1] Submitted for publication April 1963.
[2] The senior author is now with the University of California, Santa Barbara.
[3] Supported in part by a contract with the U.S. Office of Naval Research, Biology Branch (O.N.R. 03503).

Blood samples were obtained by caudal bleeding. The blood was collected and the red blood cells were washed in Alsever's physiological saline solution after the method of Sprague and Vrooman (1962). No difficulties were experienced in handling the cells, which kept well for several days in Alsever's solution at refrigerator temperatures. Sera consisted of (i) those from uninjected animals of the species indicated, termed normal sera, and (ii) anti-sera prepared by injecting rabbits with trout erythrocytes, termed immune sera. Antigenic differences were detected by slide and/or capillary tube agglutination tests. Slide tests were performed by mixing a drop of diluted serum with a drop of Alsever's solution containing a two-percent suspension of erythrocytes and allowing the mixture to stand for 20 minutes at room temperature before reading. Capillary tube agglutinations were performed by mixing an equal volume of diluted serum and an equal volume of cell suspension in a plain capillary tube. The ends were sealed with clay and the tests read after 1 hour. The degree of agglutination in individual tests was determined without magnification and was scored on a relative scale, from 4 for a strong agglutination through 3, 2, 1 to a — (negative) for no agglutination. Absorptions of individual sera were performed by mixing a diluted serum with an equal volume of erythrocytes washed and packed by centrifugation. The mixture was agitated intermittently at room temperature for periods up to an hour. The absorbed serum was separated from the cells by centrifugation. This technique was useful in removing antibodies with unwanted specificities and leaving antibodies in the serum that were reactive only with particular antigens useful in distinguishing individuals, strains, or species, depending on the case involved.

RESULTS

Reactions With Normal Sera

Erythrocytes from individual brown, Lahontan cutthroat, eastern brook, rainbow, and golden trout were tested with the normal sera of several animal species to establish the presence of the antigenic differences that are expected to exist among diverse species. The results of these tests (positive reaction +, negative reaction —) showed that the species examined, except for the brown trout which is very distinctive, form a closely related serological group (Table 1). The results also suggest that normal sera properly absorbed with individual trout

TABLE 1

Summary of Reactions of Trout Erythrocytes with Normal Sera

Trout species:	Human (type-A)	Human (type-B)	Cow	Goat	Horse	Sheep	Chicken	Goose	Pigeon	Turkey	Finback whale	Spiny lobster
Brook	+	+	+	+	—	+	—	+	—	+	+	+
Brown	—	—	—	—	—	—	—	—	—	—	—	+
Cutthroat	+	+	+	+	—	+	—	—	—	—	+	+
Golden	+	+	+	+	+	+	—	+	—	+	+	+
Rainbow (spring spawn)	+	+	+	+	+	+	—	+	—	—	+	+

erythrocytes may provide useful reagents for distinguishing intraspecific antigenic differences (Bingham, 1963). Each reaction was essentially the same for six individuals of the species tested.

Reactions With Immune Sera

Unabsorbed immune sera also distinguished antigenic differences at the species level. The serum used, anti-golden (Laurel—27), was prepared by injecting into rabbits a pool of erythrocytes obtained from golden trout taken in Laurel Lakes, and was tested in serial dilution.

TABLE 2

Individual Trout Erythrocyte Agglutination Patterns with Heteroimmune Serum, Anti-golden (Laurel—27)

		Reciprocal of serum dilution							
Species	Fish No.	32	64	128	256	512	1024	2048	Alsever's (control)
Golden Cottonwod Lakes	17,19	4	4	4	4	3	2	1	–
	18,21	4	3	3	2	1	1	1	–
	20,22,23,25,27	4	3	3	2	1	–	–	–
	24,26	4	4	3	3	2	1	–	–
Rainbow (Spring spawn)	1,2,5	4	4	3	2	1	–	–	–
	3,4	4	4	3	1	–	–	–	–
	6	4	4	2	1	1	–	–	–
Brown	1	1	–	–	–	–	–	–	–
	2,3,4,5	–	–	–	–	–	–	–	–

This serum agglutinated golden trout erythrocytes at very dilute concentrations (Table 2). In contrast, at the same concentration, brown trout erythrocytes were not agglutinated. Intermediate dilutions agglutinated erythrocytes of rainbow trout.

Reactions With Absorbed Immune Sera

The same absorption technique demonstrated antigenic differences between rainbow trout and golden trout, and in addition between rainbow spring-spawning and rainbow fall-spawning stocks.

All sera were diluted one in four and gave strong (4) reactions with all cells before being absorbed (Table 3).

TABLE 3

Agglutination Reactions Showing Examples of Distinctions Made by Absorbed Immune Sera

	Anti-golden serum (Laurel-27) absorbed with pooled spring-spawn individuals	Anti-rainbow serum (spring spawn-26) absorbed with pooled fall-spawn individuals	Anti-rainbow serum (spring spawn-26) absorbed with pooled Laurel golden individuals	Anti-rainbow serum (fall spawn-21) absorbed with pooled spring-spawn individuals
Golden (Laurel Lakes)*	4		—	
Rainbow (spring spawn)*	—	4	4	—
Rainbow (fall spawn)*		—		4

* Trout erythrocytes (pooled individuals).

TABLE 4

The Agglutination of Erythrocytes by Anti-rainbow (spring spawn-26) Absorbed with a Pool of Erythrocytes from Laurel Lake Golden Trout

Golden Trout (Cottonwood Lakes)				Golden Trout (Golden Trout Creek)		Rainbow (spring spawn)	
Fish No.	Reaction	Fish No.	Reaction	Fish No.	Reaction	Fish No.	Reaction
22	3	27	3	50	–	72	4
23	–	58	2	51	–	73	4
24	4	59	1	55	–	73	4
25	1	60	3	64	–	75	4
26	2	61	3	67	1	76	4
						77	2

A pool of erythrocytes from six golden trout (Laurel Lakes) was negative.

Immune sera from rainbow trout can be absorbed to detect variations among golden trout. For example, anti-rainbow (spring-spawning-26) serum was absorbed with a pool of Laurel Lake golden trout cells. The reactions enabled us to recognize individual antigenic differences in golden trout from the Cottonwood Lakes. Agglutination reactions with the same absorbed serum showed that an antigenic difference exists between Laurel Lakes and Cottonwood Lakes populations of golden trout (Table 4). Golden trout from Golden Trout Creek failed to react or reacted slightly in a manner similar to those from Laurel Lakes.

TABLE 5

Agglutination Reactions of Rainbow Cells with Unabsorbed Anti-Rainbow Sera

Anti-rainbow serum (spring spawn-26)										Anti-rainbow serum (fall spawn-21)									
Rain-bow spring spawn	Reciprocal of serum dilutions				Rain-bow fall spawn	Reciprocal of serum dilutions				Rain-bow spring spawn	Reciprocal of serum dilutions				Rain-bow fall spawn	Reciprocal of serum dilutions			
	32	64	128	256		32	64	128	256		32	64	128	256		32	64	128	256
108	2	1	—	—	88	2	1	—	—	108	2	1	—	—	88	3	3	2	—
109	1	—	—	—	89	2	1	—	—	109	1	—	—	—	89	3	2	1	—
110	1	—	—	—	90	3	1	1	—	110	1	—	—	—	90	4	4	3	1
111	3	1	1	—	91	3	2	1	—	111	2	1	—	—	91	3	3	2	1
112	1	1	1	—	92	3	2	1	—	112	2	1	—	—	92	3	3	2	1
113	2	1	—	—	93	1	—	—	—	113	2	1	—	—	93	2	2	1	—
114	3	1	1	—	94	3	3	1	—	114	3	3	2	1	94	3	2	2	1
115	2	1	—	—	95	2	2	—	—	115	3	2	1	—	95	3	2	2	1
116	1	—	—	—	96	2	1	—	—	116	—	—	—	—	96	3	2	1	—
117	2	1	1	—	97	2	—	—	—	117	2	2	1	—	97	2	1	1	—
118	3	2	—	—	98	2	1	1	—	118	3	2	—	—	98	3	3	2	1
119	1	—	—	—	99	2	—	—	—	119	—	—	—	—	99	3	1	1	—
120	3	2	1	—	100	2	1	—	—	120	2	1	—	—	100	3	2	1	1
121	2	2	—	—	101	1	—	—	—	121	3	2	—	—	101	1	1	—	—
122	2	—	—	—	102	2	1	—	—	122	—	—	—	—	102	3	3	2	—
123	2	—	—	—	103	1	—	—	—	123	—	—	—	—	103	2	2	—	—
124	1	—	—	—	104	—	—	—	—	124	—	—	—	—	104	—	—	—	—
125	3	3	1	—	105	1	—	—	—	125	3	2	1	—	105	1	—	—	—
126	1	—	—	—	106	—	—	—	—	126	—	—	—	—	106	2	1	—	—
127	3	—	—	—	107	2	1	—	—	127	3	2	—	—	107	3	3	1	—

TABLE 6

Reactions of Rainbow Spring Spawn Fish Cells and Anti-rainbow (Fall Spawn-21) Absorbed with a Pool of Whitney Spring Spawn Cells, 116 and 119

	Rainbow spring spawn cells														
	108	*109*	*110*	*111*	*112*	*113*	*114*	*115*	*116*	*117*	*118*	*119*	*120*	*121*	*126*
Unabsorbed	3	3	3	4	3	4	4	4	2	3	4	2	3	4	4
Absorbed	–	–	–	3	2	2	4	3	–	1	1	–	1	2	3

(All tests were made at a serum dilution of one in eight)

Antigenic differences between individual rainbow trout were studied in some detail (Table 5). The reactions of erythrocytes from the rainbow spring-spawning strain were compared with the rainbow fall-spawning strain, using dilutions of unabsorbed anti-rainbow (spring-spawning-26) and unabsorbed anti-rainbow (fall-spawning-21). The reaction patterns show that both antisera recognized individual differences, and that unabsorbed fall-spawning antiserum readily distinguished between samples of the two strains. It was possible to refine the distinctions by absorbing with cells of selected individuals from the samples (Table 6) and to show that fish of at least two antigenic types occur in rainbow spring-spawning fish. Similarly, anti-rainbow (spring-spawning-26) serum when absorbed with the erythrocytes of certain fall-spawning fish selectively agglutinated the cells of fall-spawning rainbow (Table 7). These results indicate the existence of individual variations in rainbow fall-spawning fish, and the high occurrence of one or more antigens in the spring-spawning strain, absent or of low frequency in the fall-spawning fish.

Individual Variation in Brown Trout Antigens

Serum from rabbits immunized with erythrocytes of the white croaker, *Genyonemus lineatus* (Ayres), agglutinated erythrocytes of some brown trout, but not of others, suggesting these two species share an antigen that may be useful in population studies.

TABLE 7

Reaction of Rainbow Cells with Anti-Rainbow (spring spawn-26) Absorbed with a Pool of Fall Spawn Cells from Fish 88, 89, 91, 95, and 98

Rainbow Spring Spawn Fish No.	*Reciprocal of Serum Dilution*			*Rainbow Fall Spawn Fish No.*	*Reciprocal of Serum Dilution*		
	4	*8*	*16*		*4*	*8*	*16*
108	2	1	–	88	–	–	–
109	2	1	–	89	–	–	–
110	2	1	–	90	2	–	–
111	2	1	–	91	1	–	–
112	2	1	–	92	–	–	–
113	2	1	–	93	–	–	–
114	1	1	–	94	–	–	–
115	1	1	–	95	–	–	–
116	2	1	–	96	–	–	–

DISCUSSION

Data developed in this study show that, like salmonids cited in the literature, California trouts differ in the antigenic specificities of their erythrocytes. Their diversity was used in this study to demonstrate differences between individuals in the same population, between samples of individuals from different populations of the same species, and between samples of individuals from different species. These differences could be used in studying the ecology and evolution of the endemic golden trout, the hybridization of species in the wild, the survival of planted trout, and the culture and relative fitness of distinctive physiological strains. The spring- and fall-spawning rainbow stocks are examples of the latter.

It seems highly probable that erythrocyte antigens will provide valuable genetic markers in a variety of experimental situations in which either the biology or the results of management techniques are not fully understood.

SUMMARY

The erythrocyte antigens of rainbow, golden, brown, and cutthroat trout were studied. The trout displayed a high degree of antigenic diversity useful for characterizing species, strains, and individuals. Such diversity forms recognizable markers that could be used to advantage in a number of studies related to the biology and management of California trouts.

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OBSERVATIONS ON THE FOOD OF FINGERLING LARGEMOUTH BASS IN CLEAR LAKE, LAKE COUNTY, CALIFORNIA[1]

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Clear Lake, a 40,000-surface-acre, seminatural lake situated in central Lake County at an elevation of 1,325 feet, contains an assemblage of native and exotic warmwater fishes. Murphy (1951) presented a general description of the lake and the history of its fishery. Fishing success has varied considerably through the years (Murphy, 1951; Pintler, 1957).

Since 1948, management efforts to improve the largemouth bass *(Micropterus salmoides)* fishery have resulted in liberalized angling regulations to increase the catch (a minimum size limit for largemouth bass was eliminated and night fishing for all species was allowed), and in attempts to maintain, establish, and improve cyprinid forage fish populations.

The hypothesis that prompted these latter efforts was developed and described by Murphy (1951). He concluded that a close correlation existed between the survival of bass-of-the-year and the strength of that year's crop of cyprinid forage fish, and theorized that the Clear Lake bass population could be increased by augmenting the supply of the forage species.

His hypothesis was based in part on a study of the food habits of bass-of-the-year at Clear Lake during mid-August 1948 (Murphy, 1949). This study demonstrated that fish were the primary food of young bass over 2.8 inches fork length, and indicated that the Sacramento blackfish *(Orthodon microlepidotus)* was the most important species consumed. Bluegill *(Lepomis macrochirus)* fry, though abundant, appeared relatively unimportant as forage for young bass.

Inasmuch as there was evidence the native cyprinid populations had been seriously reduced since the early 1940's, it was recommended that these species be protected. As a result, the commercial blackfish fishery that had been operating on the lake for many years was banned in September, 1948.

A nonnative forage fish, the golden shiner *(Notemigonus crysoleucas)*, was introduced in 1950 to augment the supply of native minnows.

The value of blackfish as forage has continued to be a subject for considerable debate. In 1954, an apparent increase in the blackfish population led the California Fish and Game Commission to permit a limited harvest of mature blackfish by commercial fishermen. This intensified the controversy over the forage fish problem.

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In the hope of resolving this problem, additional food habit studies, closely comparable to that of 1948, were conducted in mid-August of 1956, 1957, and 1958.

The objectives of the 1948 study were to determine what food habit changes occurred as the bass increased in size, what forage fish species were most utilized by fingerling bass, and the extent of cannibalism within the year-class. The later studies were designed primarily to test the conclusions of the earlier study.

Fingerling bass were collected and their stomach contents analyzed in 1956, 1957, and 1958 by McCammon (1957), McCammon and LaFaunce (1958), and LaFaunce (1959), respectively. These workers prepared the original draft of the present paper, but final responsibility for its total content rests with the second junior author (C.M.S.).

This paper, taken largely from these earlier reports, summarizes and compares the results of all four Clear Lake studies. Additionally, it relates these results to pertinent information from other areas.

PROCEDURES

The equipment and procedures used in all four studies were essentially the same. All of the specimens were collected with a 40- by 6-foot, ¼-inch bar measure seine along the northwest shore of the lake between the town of Lakeport and Rodman Slough. The collection dates were: August 10-12, 1948; August 13-14, 1956; August 21-22, 1957; and August 21-22, 1958. In the 1948 collection, selection was exercised in order to obtain adequate numbers of fish of all sizes (Murphy, 1949), but no size selection was exercised in the later collections. All of the specimens were preserved in formalin and taken to the laboratory for stomach analysis. In the 1957 and 1958 collections, these specimens were suffocated in a tub of water before preservation to reduce regurgitation of food.

Fork length was recorded for each fish. Stomach contents were stored and classified, and an effort was made to identify each forage fish to species. In the last three studies, fish remains that were unidentifiable from external features were cleared and stained in a mixture of potassium hydroxide and alizarine red S in order to facilitate recognition.

Frequency of occurrence and volume of each food category were recorded in the analysis of each study. The number of individual food items was also recorded during the 1957 and 1958 studies. When it was impractical to count the total number of a certain organism in a stomach (e.g., cladocerans), the number was estimated. Volumetric determinations were obtained by measuring water displacement, using graduated centrifuge tubes.

RESULTS

Bass sizes varied considerably in the different collections (Table 1), even though they were made at approximately the same time of year. Size selection in the 1948 sample probably biased that distribution toward the larger sizes. Since size selection was not exercised in the later collections, the length frequencies for those studies probably

TABLE 1

Length Frequency Distributions of Largemouth Bass-of-the-year Collected in Clear Lake in August, 1948, 1956, 1957, and 1958

Fork length (inches)	*Number of fish collected*			
	1948	*1956*	*1957*	*1958*
1.3 - 1.4	8	—	—	—
1.5 - 1.6	22	10	1	—
1.7 - 1.8	12	43	1	1
1.9 - 2.0	26	68	7	9
2.1 - 2.2	46	60	10	6
2.3 - 2.4	43	31	27	10
2.5 - 2.6	21	20	25	22
2.7 - 2.8	13	7	28	17
2.9 - 3.0	11	6	25	24
3.1 - 3.2	13	3	22	24
3.3 - 3.4	9	1	12	11
3.5 - 3.6	7	2	22	16
3.7 - 3.8	11	—	10	12
3.9 - 4.0	4	—	10	20
4.1 - 4.2	4	—	17	22
4.3 - 4.4	6	—	3	15
4.5 - 4.6	2	—	2	18
4.7 - 4.8	1	—	2	12
4.9 - 5.0	—	—	—	6
5.1 - 5.2	—	—	—	6
5.3 - 5.4	—	—	—	4
5.5 - 5.6	—	—	—	5
5.7 - 5.8	—	—	—	—
5.9 - 6.0	—	—	—	1
Totals	259	251	224	261
Mean fork length (inches)	2.5	2.1	3.0	3.6

reflect fish sizes in the study area. Differences in mean sizes of the fish in the collections had a decided effect upon the kinds of food consumed.

In all of the studies, fish were the most important food from the standpoint of volume, ranging from 56 percent in 1956 to almost 99 percent in 1958. The amount of fish in the total volume of food consumed was roughly proportional to the mean size of the fish, whereas the inverse was true for insects and crustaceans.

A definite change in food habits with increasing size of the young bass was noted in all collections (Figures 1 and 2). (In the 1948 study, 10 specimens with empty stomachs were included in the graphs, while in the later studies only those specimens which actually contained food were used.)

The data from the later studies on the transition of food habits with increasing size of the bass substantiate the data from the 1948 study. Crustaceans and insects were the primary foods of smaller bass, while fish became of major importance as the bass grew. The length at which this shift in diet occurred varied somewhat among the four studies, being about 3.0 inches in 1948, 2.5 inches in 1956, 3.0 inches in 1957, and 2.0 inches in 1958. In all of the studies, bass over these sizes consumed food items in addition to fish, but the amounts were minor.

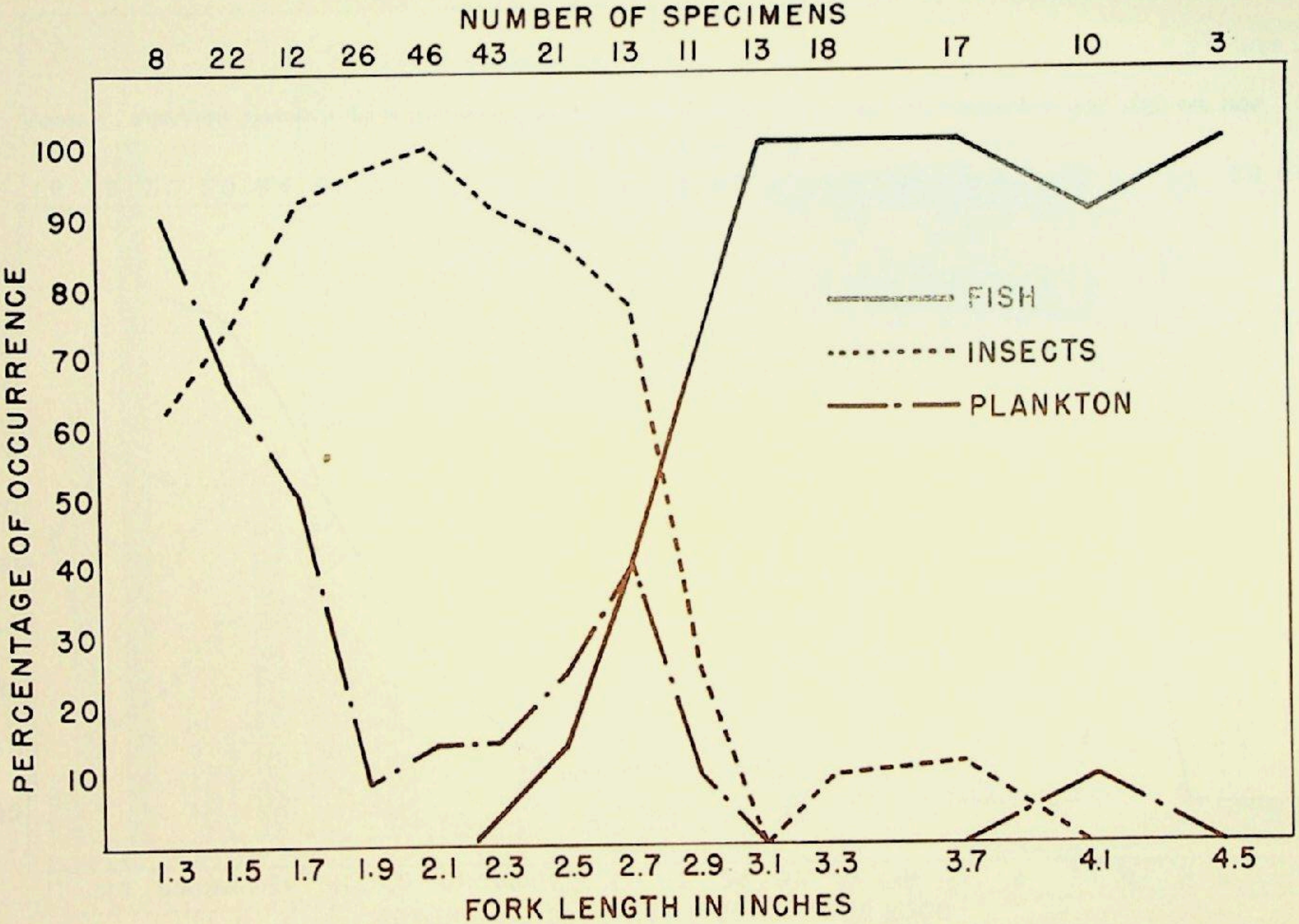

FIGURE 1. Composition of the stomach contents of fingerling largemouth bass. (After Murphy, 1949.)

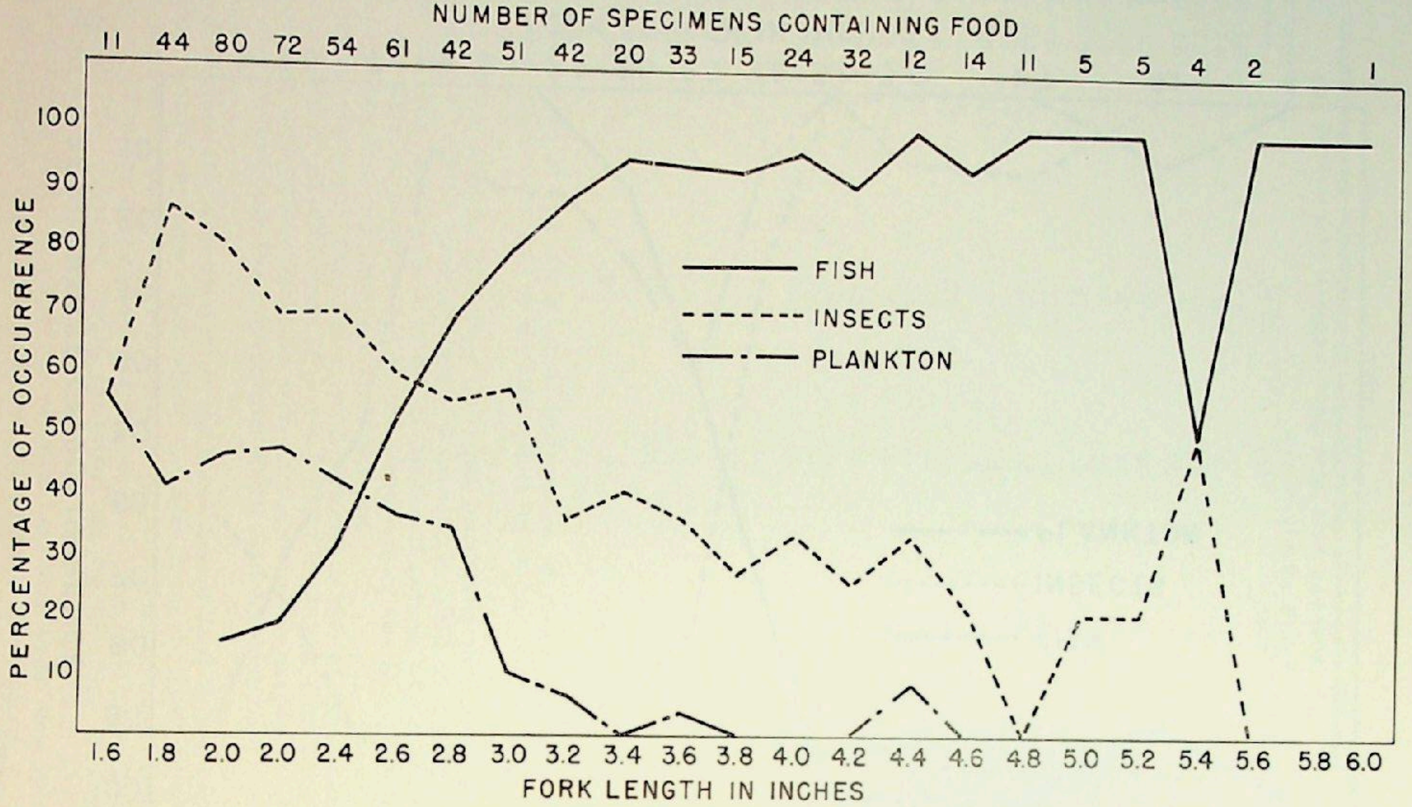

FIGURE 2. Relationship between length of largemouth bass and consumption of major food items during mid-August 1956, 1957, and 1958.

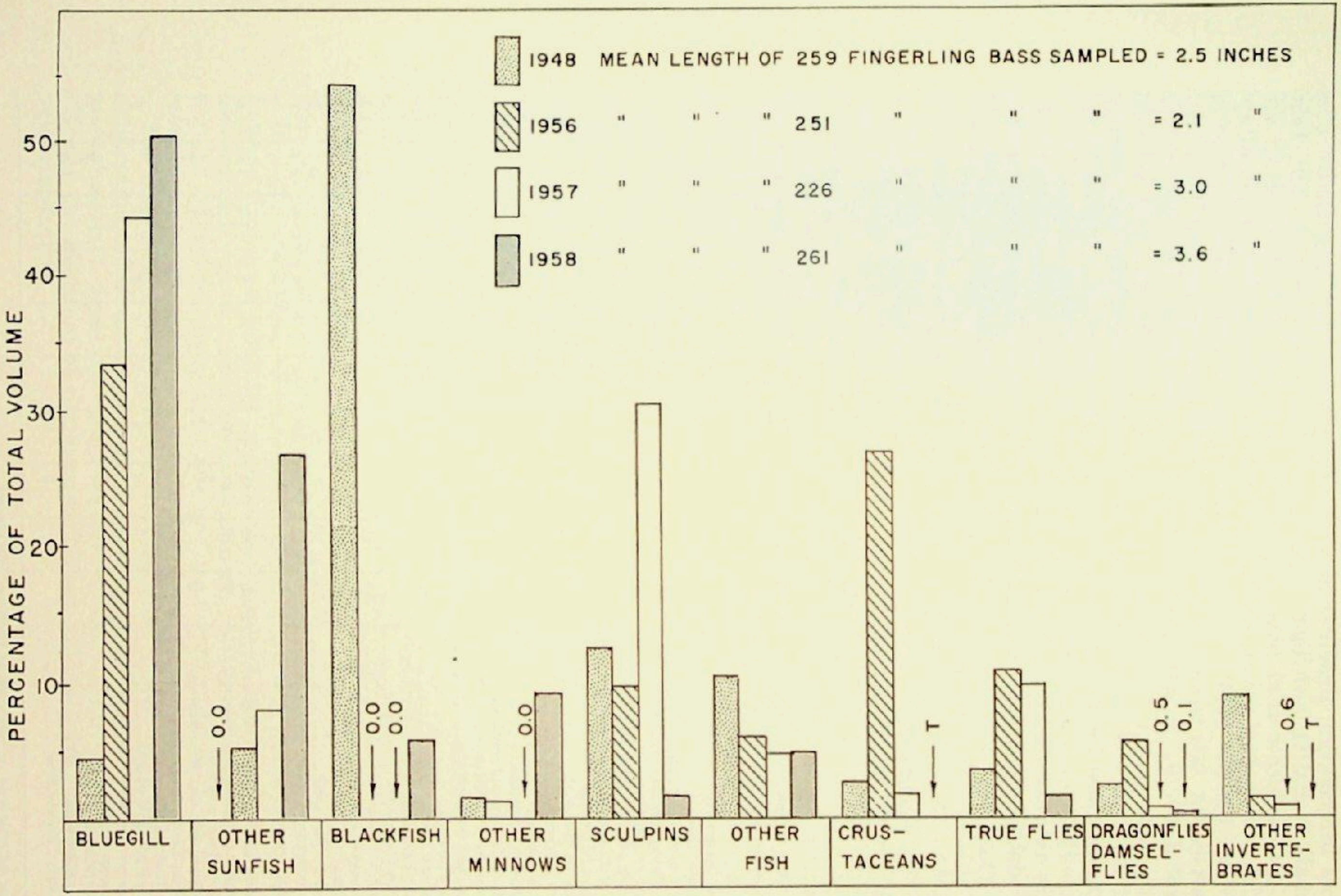

FIGURE 3. Volumetric comparison of food items consumed by fingerling largemouth bass in Clear Lake, 1948, 1956, 1957, and 1958.

This information provides additional evidence that largemouth bass as small as 2.0 inches long can utilize suitable forage fish. The 1958 data also indicate that bass will switch to a fish diet at a length appreciably less than the commonly accepted 3 inches, if forage fish of appropriate size are available. Kramer and Smith (1960) reported that in Lake George, Minnesota, a few largemouth bass fingerlings in a size group of 20-29.9 mm (0.8-1.2 inches) contained fish remains. Nelson (1962) also found fish in the diet of small largemouth bass at Fort Randall Reservoir, South Dakota. He observed that after bass reached 2.5 inches total length fish became their primary food. Apparently the limiting factors are the size and availability of the forage species.

The greatest divergence between the 1948 Clear Lake study and the later data from the same water is in the relative amounts of specific food organisms consumed (Table 2). In 1948, blackfish comprised 65

TABLE 2

Food Consumed by Largemouth Bass Fingerlings in Clear Lake

Food item	Number of organisms*		Frequency of occurrence				Volume (cc.)†			
	1957	1958	1948	1956	1957	1958	1948	1956	1957	1958
Fish										
Sunfish (Centrarchidae)										
Bluegill (*Lepomis*)	38	108	6	27	35	84	3.1	6.2	13.8	43.5
Green sunfish (*Lepomis*)	1				1				0.2	
Unidentified sunfish (*Lepomis*)		11				11				5.6
Black crappie (*Pomoxis*)				1				0.2		
Largemouth bass (*Micropterus*)		1				1				0.1
Unidentified centrarchid remains	14	145		5	14	90		0.8	2.3	17.5
Minnows (Cyprinidae)										
Blackfish (*Orthodon*)		1	28			1	37.8			5.0
Carp (*Cyprinus*)		2	1			2	1.0			2.4
Hitch (*Lavinia*)		4				4				5.3
Squawfish (*Ptychocheilus*)				1				0.2		
Unidentified cyprinid remains		1				1				0.2
Topminnows (Poeciliidae)										
Mosquitofish (*Gambusia*)		11		1		9		0.2		1.3
Sculpins (Cottidae)										
Sculpin (*Cottus*)	37	4	15	5	33	3	8.8	1.8	9.5	1.3
Catfish (Ictaluridae)										
Unidentified catfish (*Ictalurus*)		1				1				0.3
Unidentified fish remains	16	41	24	8	16	39	7.2	0.9	1.5	2.7
Crustaceans										
Waterfleas (Cladocera)	10,000	13	53	101	63	5	1.3	2.0	0.1	T
Amphipods (Amphipoda)	227	9	35	129	33	6	0.4	3.0	0.4	T
Insects										
True flies: arvae and pupae (Diptera)	2,682	962	65	141	112	84	2.3	2.0	3.0	1.0
Dragonflies and damselflies (Odonata)	7	10	32	50	7	5	1.4	1.0	0.1	0.1
Mayflies (Ephemeroptera)			8	4			0.1	T		
Wasp, bees, ants, etc. (Hymenoptera)	2			1	2			T	T	
True bugs (Hemiptera)	1	1			1	1			T	T
Water boatmen (Corixidae)	2		142	17	2		6.0	0.2	T	
Unidentified insect remains		3	6	2		3	0.1	T		T
Miscellaneous invertebrates										
Spiders (Arachnida)	2				2				T	
Leeches (Hirudinea)	3				3				0.2	
Unidentified invertebrates			8	4			0.1	T		

* Number of organisms not recorded in 1948 or 1956 studies.
† T = trace.

percent of all fish eaten and 54 percent of the total volume of food. No blackfish were found in the 1956 and 1957 collections, and only one was found in 1958. Bluegills were relatively unimportant in 1948, comprising only 5 percent of the fish and only about 4 percent of the total food. By contrast, bluegills comprised the majority of the fish and were the most important single food item consumed in each of the later studies (Figure 3).

Cyprinids were important in the bass diet only in the 1948 and 1958 studies, but to a much lesser degree in the latter. In 1948, blackfish made up 54.2 percent and carp (*Cyprinus carpio*) 1.4 percent of the total volume of food. In 1958, cyprinids composed 15.1 percent of the total volume, one-third of which consisted of a single 2.5-inch blackfish that had been eaten by a 5.0-inch bass.

Sculpins (*Cottus*) were of considerable importance in all but the 1958 study, when they composed only 1.5 percent of the total volume. This evidence, coupled with data that show sculpins are important food for white catfish (*Ictalurus catus*) (George W. McCammon, unpublished data), indicates they may be an important forage fish in Clear Lake from the standpoint of consistent utilization.

Crustaceans were of minor importance in the diet of the bass in all but the 1956 collection, in which cladocerans made up 11 percent and amphipods 16 percent of the total food volume. This is not surprising when related to the mean size of the bass in the 1956 collection (2.0 inches) and to the fact that microcrustaceans are utilized primarily by small fish.

Dipteran larvae and pupae made up the bulk of the insect food consumed in all collections but 1948, when water boatmen (Corixidae) were the most important insect, with dipterans second.

The only evidence of intra-year-class cannibalism was found in 1958, when one bass had been consumed.

DISCUSSION

As a general rule, food habit studies in which specimens are collected in a restricted area during a brief period of time do not provide adequate data upon which to base definite conclusions. At best, this type of collection indicates only the amounts and kinds of foods consumed at a given time and place. Projection of such data may seriously distort the true picture of the relationships involved. The fingerling bass food habit studies reported here follow this rule.

In some instances, short-term investigations will uncover sufficient facts to support a working hypothesis. However, to obtain an accurate picture of the food habits of an organism, collections must be made at regular intervals over at least one and preferably two or more growing seasons or years.

The four brief food habit studies reported herein have only limited application to the management of the Clear Lake fishery. Past environmental control practices based on the results of the 1948 study, specifically the abolition of commercial fishing for blackfish, may not have been warranted.

The following conclusions drawn from the 1948 study were inconsistent with the results of the later studies:

1) Bluegill fry are not important in the diet of bass in Clear Lake.
2) The Sacramento blackfish is a highly important forage and buffer species in Clear Lake.
3) The selection of food items by bass in Clear Lake is primarily a matter of choice and not of environmental limitations.

The first of these conclusions conflicts with the results obtained during the three later studies, as well as with considerable evidence from other waters, both in and out of California.

J. B. Kimsey (unpublished data) made fingerling bass stomach collections at regular intervals throughout two growing seasons in Salt Springs Valley Reservoir, Calaveras County. He found that although golden shiners and fathead minnows *(Pimephales promelas)*, usually considered desirable forage species, were present in the reservoir, they were eaten only in insignificant quantities. Bluegill fry, on the other hand, were the forage species of greatest importance.

Brief bass food habit studies at Lake Havasu (Beland, 1954) and Millerton Lake (Fisher, 1951) also demonstrated that largemouth bass utilize bluegills as forage.

In an evaluation of the threadfin shad *(Dorosoma petenense)* in the lower Colorado River, Kimsey *et al.* (1957) found that bluegills and other centrarchids occupied a prominent position in the diet of largemouth bass, even in the presence of the abundant shad.

Kramer and Smith (1960) noted that in Lake George, Minnesota, the forage species most commonly taken by fingerling bass were young-of-the-year sunfish and brook silversides *(Labidesthes sicculus)*, although the lake contained other species, including perch, darters, and minnows.

Ball (1948) found that bluegills were the staple food of largemouth bass in Third Sister Lake in Michigan, although several species of small minnows and darters were also abundant.

Murphy (1949), noting that bluegills spawned 1 to 1½ months after the bass, cited this as a point against their usefulness as bass forage. Actually, the fact that bluegills are late spawners helps to substantiate the opposite view. By spawning late, large numbers of small bluegills are present when fingerling bass are ready to change from an invertebrate to a fish diet.

In 1949, a detailed life-history study of the blackfish showed that they spawn before, or about the same time, as the bass, and that the young-of-the-year grow very rapidly (Murphy, 1950). During that year, the Age 0 blackfish attained an average fork length of approximately 2.9 inches by mid-August. If this growth rate is typical, it seems very unlikely that the bulk of Age 0 blackfish would be suitable forage for bass-of-the-year. The average fork lengths of fingerling bass around mid-August in 1948, 1956, 1957, and 1958 were 2.5, 2.1, 3.0, and 3.6 inches, respectively (Table 1). Any predator-prey relationship between Age 0 bass and Age 0 blackfish would be restricted to the larger bass and the smaller blackfish.

Unfortunately, only rough approximations give any clue to the relative abundance of blackfish or bluegills during the study periods. In three of the studies bluegills were termed abundant or very abundant in the study area, while young blackfish were scarce or completely absent (estimates of the abundance of either species were lacking in the 1957 study). Obviously, more precise information about relative abundance would have given greater weight to the conclusions reached.

White catfish are important predators in Clear Lake. Nevertheless, analysis of the stomach contents of several hundred Clear Lake white catfish in 1943 (Wales, 1943) failed to detect a single blackfish. In addition, examination of 115 white catfish stomachs collected at intervals in 1953 and 1954 from Clear Lake further indicate that catfish do not feed on blackfish (George W. McCammon, unpublished data).

Murphy (1949) detected no evidence of intra-year-class predation among bass during his study. He theorized that the factors of "availability and desirability, that mitigated against the full utilization of young bluegill, operated in the case of smaller bass." In addition, he advanced the hypothesis that in the absence of an early spawned cyprinid forage fish, the brunt of predation by older bass would be borne by bass fry.

The contention that the blackfish is a valuable buffer species, though possible, can be neither confirmed nor denied, since conclusive evidence in the form of food habit studies of larger Clear Lake bass does not exist. With the exception of one fish in 1958, the 1948 study is the only record available in which bass consumed blackfish.

In at least one instance, introduction of Sacramento blackfish into a warmwater lake in California was detrimental to a largemouth bass fishery (Douglas, 1949). An accidental introduction of blackfish into Lake Hughes, Los Angeles County, resulted in a decline in the quality of bass angling and a population eventually dominated by blackfish. It later became necessary to remove the entire population of Lake Hughes and adjoining waters by chemical treatment.

The importance of blackfish in the diet of bass-of-the-year at Clear Lake in August 1948, and the relative unimportance of the bluegill as a forage species during the same period, cannot be denied. However, succeeding food habit studies in Clear Lake, as well as many studies from other waters, indicate that this situation was atypical. Subsequent evidence showed that the blackfish is not regularly an important forage species. Nevertheless, the possibility exists that blackfish could again become important under conditions similar to those in Clear Lake in 1948. It is of interest to note that the 1948 sample was taken before elimination of the commerical blackfish fishery and during a period when the blackfish population was thought to be depleted.

With the exception of the apparent selection of blackfish by bass during the first Clear Lake study, it appears most likely that the primary factor in the utilization of a food organism by bass is the availability of a suitable sized organism. The variation in size at which the bass in each study turned to a predominantly fish diet, as well as the varying species composition in the different collections, supports this conclusion. Support also can be found in Kramer and Smith (1960), who also found that the utilization of a food organism was dependent upon its size and availability. This conclusion should be qualified, however, in that choice can play a part in food selection when food items are equally available. Lewis *et al.* (1961), in a laboratory study, found that largemouth bass usually ate golden shiners, apparently preferring them to several other organisms of similar size and availability.

SUMMARY

A study of fingerling largemouth bass food habits in Clear Lake during mid-August, 1948, indicated the Sacramento blackfish was a far more important forage and buffer species than the bluegill.

To obtain a better understanding of bass-forage fish relationships in Clear Lake, and to test conclusions of the earlier study, additional investigations were conducted in mid-August of 1956, 1957, and 1958. Areas sampled, sampling methods, and subsequent analyses employed in these studies duplicated those of the 1948 study when possible.

The data from all four studies which relate the transition of food habits to changes in size are in agreement. Plankton and insects were the most important food for bass under 2.5 inches fork length, while fish became the major food for bass above that size.

The mean lengths of the bass sampled ranged from 2.1 inches in the 1956 collection to 3.6 inches in the 1958 collection. These differences influenced the proportions of the major food items (i.e., fish, crustaceans, and insects) consumed. The larger bass ate more fish and the smaller ones more insects and crustaceans.

The greatest differences in food habits were in the specific kinds of food eaten. In the 1948 collection, blackfish were the major food item with bluegills of only minor importance. In all of the later collections, bluegills constituted over half of the fish consumed, and were the most important single item. On the other hand, blackfish, with one exception, were not found in any of the stomachs examined during the later studies. Therefore, we conclude that blackfish are not regularly important forage for fingerling largemouth bass in Clear Lake.

We also conclude that, while species preference may play a part in the selection of a food organism by fingerling largemouth bass, size and availability are more important.

These studies emphasize the desirability of follow-up work when a management program is based on very limited data.

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READFIN SHAD, *DOROSOMA PETENENSE*, AS FOOD OF YEARLING CENTRARCHIDS[1]

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INTRODUCTION

The purpose of this paper is to report an apparent failure of threadfin shad to provide adequate forage for yearling largemouth bass, *Micropterus salmoides*, and black crappie, *Pomoxis nigromaculatus*, in a 50-acre fishing impoundment.

Pena Blanca Lake, the site of the fishery under discussion, is in Santa Cruz County, Arizona. It has been described previously (McConnell, 1963; Gerdes and McConnell, 1963). Shad, bass, and crappie were stocked when the impoundment first filled in the spring of 1958. Food habits and spawning of the shad in Pena Blanca Lake have been reported (Gerdes and McConnell, 1963).

METHODS

The centrarchids were captured by angling, electrofishing, and gill netting, primarily during the summer (Table 1). Fish near the length modes of collections were selected when an entire collection was not used in the analysis (1961 only). Length frequencies indicate that most of the fish studied were near the end of their first year of life or in their second (McConnell, 1963). The modal groups formed by yearlings dominated the centrarchid population in all years but 1960, when young-of-the-year largemouth bass were preponderant. Volume of shad consumed is reported as the reconstructed pre-ingestion volume. Reconstruction was based upon the relationship of volume to the combined length of the five caudal vertebrae preceding the hypural plate (Figure 1). Caudal vertebrae of shad, easily distinguished from those of other

TABLE 1

Month and Method of Collecting Centrarchids and Number of Stomachs Examined *

Species	Year	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.
Largemouth bass	1959	7,T	5,T		23,H	7,H	3,H			
Largemouth bass	1960					1,T	10,T		4,T	10,E
Largemouth bass	1961		10,E		20,H	21,H	12,H	10,H		
Black crappie	1960					1,T	21,T		2,T	9,E
Black crappie	1961			10,T	22,H	16,H	14,H	7,H		

* T = throw net; H = hook and line; E = electrofishing.

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fish in Pena Blanca Lake, were frequently all that remained for identification. Volume of arthropods was determined as the settled volume in a graduated centrifuge tube. Settled volume, including interstices, probably is a closer approximation of pre-ingestion volume than volume of water displaced when exoskeletons are the principal remains.

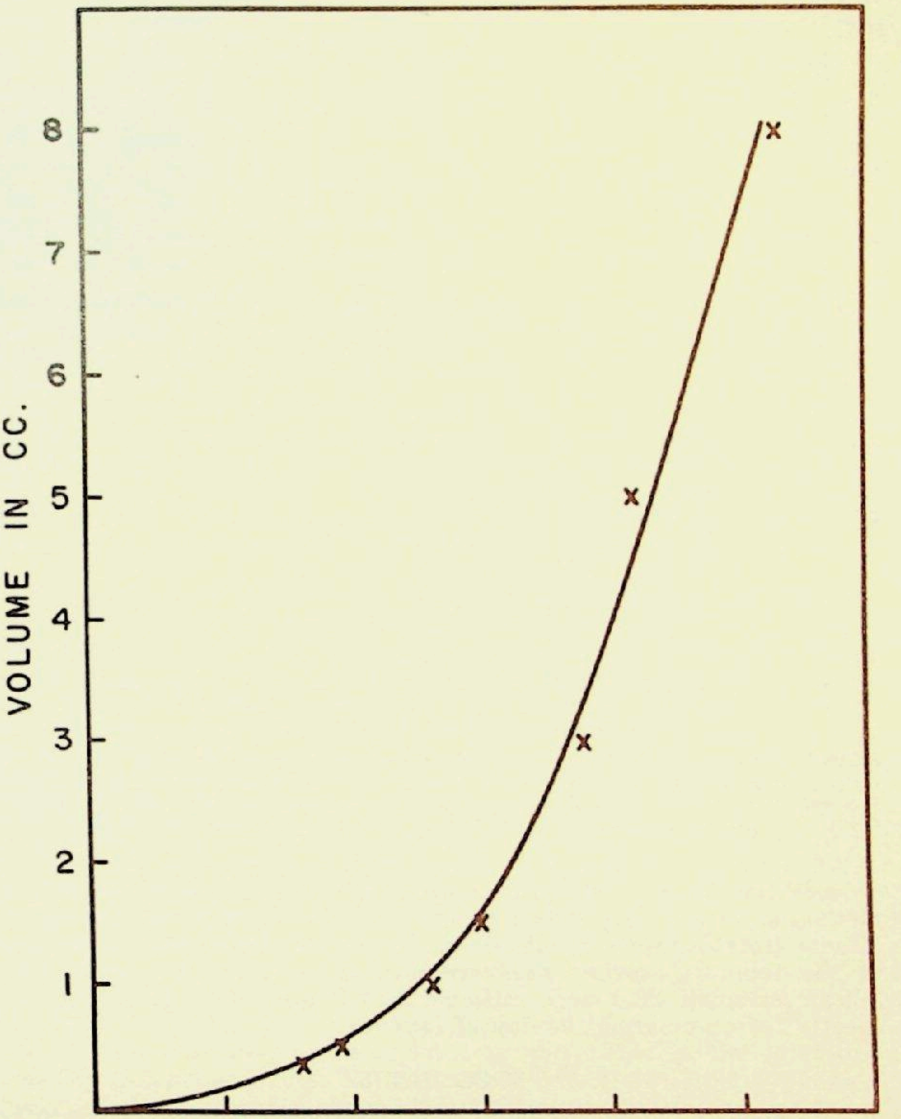

FIGURE 1. Relationship of volume to length of 5 terminal vertebrae of 7 threadfin shad. The curve was fitted by eye.

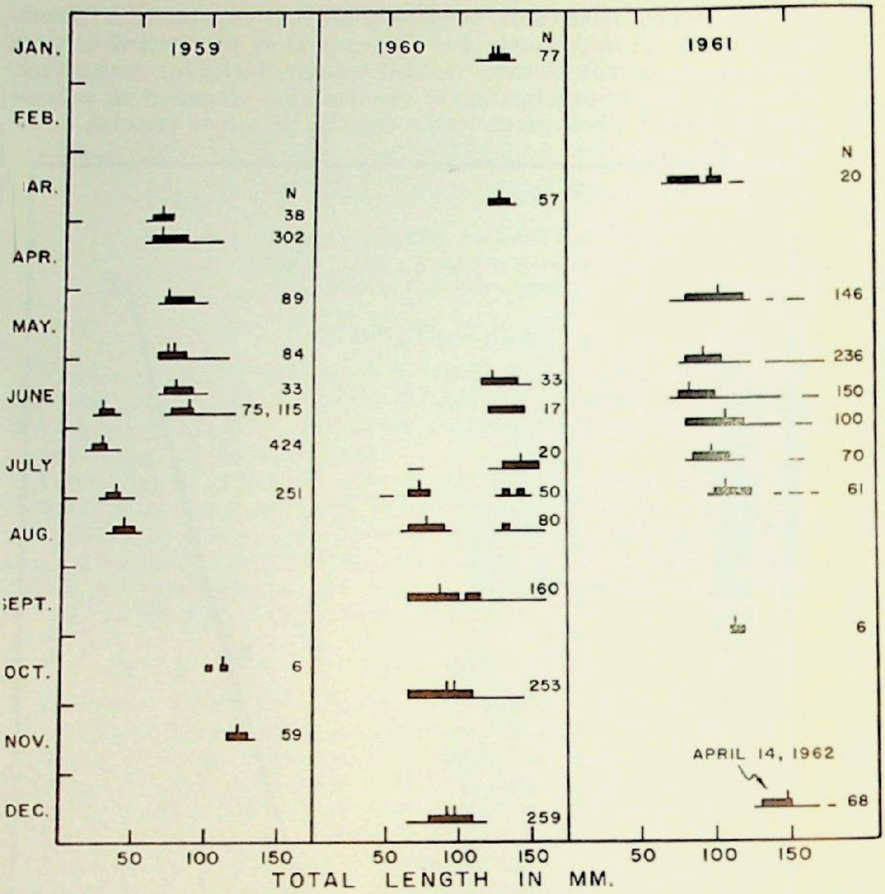

FIGURE 2. Length frequencies of threadfin shad in Pena Blanca Lake. The width of the rectangles represents the range of total lengths including 80 percent of samples, the horizontal lines extending from the bases of rectangles represent the total range of lengths, and vertical dashes indicate the positions of modal 5 mm length groups. Column under N indicates sample size.

Numbers of shad used in the length frequency analysis, and time and method of capture are shown (Figure 2). The absence of shad under 50 mm (total length) in collections between mid-August and mid-June of the following spring was corroborated by extensive observation. Whenever small shad were collected in gill nets, they were also seen shortly before or after the day of capture.

FOOD HABITS

Arthropods (cladocerans and insects) occurred much more frequently than shad in the diet of yearling centrarchids in Pena Blanca Lake (Table 2). The relatively few shad eaten contributed an important increment to the total volume of food consumed, but were still second to arthropods by this criterion. Murphy (1949) found that both volume

TABLE 2

Major Centrarchid Foods in Pena Blanca Lake

Species	Year	Stomachs examined	Total length range (mm)	Threadfin shad			Cladocerans		Insects		Number empty
				Percent vol.	Percent occ.	No.	Percent vol.	Percent occ.	Percent vol.	Percent occ.	
Largemouth bass	1959	45	116–120	--	13.0	20	--	9	--	66	11
Largemouth bass	1960	25	85–128	40	8.0	4	21	32	38	75	4
Largemouth bass	1961	73	109–195	27	1.4	1	25	41	47	74	5
Black crappie	1960	32	71–147	35	1.5	8	49	62	15	60	6
Black crappie	1961	68	135–198	0.0	0.0	0	78	84	22	72	4
All centrarchids	1959-61	243	76–200	--	5.8	33	--	49	--	60	30

and numbers of fish greatly exceeded those of arthropods in the diet of 3.5- to 5-inch largemouth bass in Clear Lake, California. Kutkuhn (1955) and Reid (1950) presented similar findings for black crappie over 4 inches TL.

Largemouth bass between 2.5 and 5 inches in Clear Lake were found by Murphy (1949) to contain an average volume of 0.39 cc of fish each. Largemouth bass from Pena Blanca Lake in the same size range contained an average volume of all foods of only 0.27 cc. This comparison suggests that largemouth bass in Pena Blanca Lake were deprived of an important increment of food by the unavailability of small forage fish.

Length frequencies of shad provide a possible explanation for their relative scarcity in the diet of yearling centrarchids (Figure 2). During the three years of study no shad under 50 mm TL were observed or collected during the spring or during September and October. Therefore, during at least 5 of the 8 months with water temperatures above 60° F., yearling centrarchids probably had difficulty finding fish they could eat. Stomach samples indicated that shad which exceeded half the length of the centrarchid predator were not often eaten successfully (Table 3). Several unverified reports were received of bass dying while attempting to eat large shad. One dead bass, with a shad lodged in its throat, was found by a fisherman and given to project personnel (Table 3). Examination revealed the shad could not be regurgitated because of its belly scutes.

The principal causes of small shad scarcity in Pena Blanca Lake are apparently a single, short spawning period and subsequent rapid growth of young-of-the-year (Figure 2). Shad in Pena Blanca Lake did not spawn before mid-May in 1959, 1960, and 1961 (Gerdes and McConnell, 1963). Most spawning was completed by early July in 1961 and presumably in 1959 and 1960. No evidence of later spawning by young-of-the-year was detected during 1959, 1960, and 1961. But length frequency modes (60-80 mm) during the spring of 1959 suggested late spawning in 1958 by young-of-the-year. Kimsey et al. (1957) reported spawning by shad-of-the-year in California.

TABLE 3

Predator-Prey Length Relationship of Centrarchids and Threadfin Shad

Predator	Date	Number eaten	Total length of predator (mm)	Total length of prey (mm)	Length ratio prey/predator
Largemouth bass	March 28, 1959	1	200	not meas.	not det'd.
Largemouth bass	June 6, 1959	1	177	not meas.	not det'd.
Largemouth bass	June 6, 1959	1	177	not meas.	not det'd.
Largemouth bass	June 6, 1959	1	177	not meas.	not det'd.
Largemouth bass	June 24, 1959	1	177	not meas.	not det'd.
Largemouth bass	July 10, 1959	15	183	all <50	all <0.27
Largemouth bass	July 7, 1960	1	107	50	0.47
Largemouth bass	Aug. 3, 1960	3	109	47, 46, 40	0.43, 0.42, 0.37
Largemouth bass	Aug. 8, 1961	1	187	98	0.51
Largemouth bass	Unknown	1 (attempted)*	178	103	0.57
Black crappie	Aug. 3, 1960	4	80	31, 36, 31, 31	0.39, 0.45, 0.39, 0.39
Black crappie	Aug. 3, 1960	1	82	40	0.49
Black crappie	Aug. 3, 1960	1	84	31	0.37
Black crappie	Aug. 15, 1960	1	98	50	0.51
Black crappie	Aug. 15, 1960	1	105	36	0.34
Totals		34			

* The largemouth bass died when a threadfin shad became stuck in its throat.

Shad-of-the-year usually attain sexual maturity, but do not ripen, by late October in Pena Blanca Lake. Apparently ripeness is impaired by prevailing temperatures under 65° F. from early November through April. January water temperatures as low as 42° F. in Pena Blanca Lake may also inhibit early ripening in the spring.

Extensive observation supported the absence of shad-of-the-year in 1961 collections (Figure 2). In 1959 and 1960, abundant young-of-the-year were very obvious from late June to early August even when temporarily difficult to collect. This was not true in 1961. Although spawning was extensive, no young were detected in the lake. Eggs returned to the laboratory in 1961 hatched successfully, indicating some other factor was responsible for the year-class failure. Gill-netting in April 1962 supported observations of no survival from the 1961 year-class (Figure 1). Meteorological and limnological conditions (including insolation, wind, inflow, p^H, T.D.S., primary productivity, light penetration, dissolved oxygen, and stratification) in 1959 and 1960 were similar in 1961. The only major difference existed in the fish population. For the first time there was a large population of yearling black crappie, and the adult shad population was much greater than it had been in previous springs. Possibly, predation on larvae by either of these groups was more intensive than usual, and eliminated the year-class.

In addition to failing to provide forage for yearling centrarchids, there is evidence that shad may compete with centrarchids for cladocerans. Gerdes and McConnell (1963) found that cladocerans were preponderant in the diet of shad in Pena Blanca Lake. Large numbers of adult shad occurred there throughout the study.

ACKNOWLEDGMENTS

This study is a contribution of the Arizona Cooperative Wildlife Research Unit. Funds were provided by the Arizona Game and Fish Department through Federal Aid to Fish Restoration Project F-8-R, Pena Blanca Studies, and by the University of Arizona. Student assistant Dale Schumacher gave substantial help collecting and tabulating data.

SUMMARY

During a 3-year study, stomachs of 143 largemouth bass and 100 black crappie between 75 mm and 200 mm (TL) revealed that occurrence of threadfin shad never exceeded 13 percent for either species. Although important in total volume of food consumed, shad were outranked by arthropods in the diets of both centrarchids in 1960 and 1961. In volume threadfin shad averaged 33 percent of the largemouth bass diet and 17 percent of the crappie diet during these years. Arthropods, mainly cladocerans and insects, made up the remainder of the diets. Rapid growth of threadfin shad after one short spawning period in late spring was postulated as a probable reason for their infrequent use as food by yearling centrarchids. Failure of the shad to produce a year-class in 1961 was also important.

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AN ECOLOGICAL SURVEY OF A MARINE ENVIRONMENT PRIOR TO INSTALLATION OF A SUBMARINE OUTFALL[1]

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Marine Resources Operations
California Department of Fish and Game

INTRODUCTION

The California Department of Fish and Game and State Water Pollution Control Board entered into an agreement May 1, 1962, whereby Department biologist-divers made an ecological study of the marine environment in the vicinity of Canyon de las Encinas, San Diego County, California.

The study provided the State Water Pollution Control Board with background information on conditions in the area prior to discharge of community wastes through a submarine outfall. Field work was conducted in May and June, 1962, and a final report furnished the State Board in August 1962. The Board reimbursed the Department for expenses incurred during the study.

Studies of this type usually have been conducted after ocean outfalls have operated for considerable periods. Since our study was unique in the sense it was conducted before construction, and employed relatively new techniques, we felt it merited formal publication.

AREA DESCRIPTION

The study area lies approximately midway between Agua Hedionda and Batiquitos Lagoon in northern San Diego County. The shoreline is a smooth, narrow beach backed by sandstone cliffs. Seaward, the ocean floor slopes gently, reaching 100-foot depths approximately 5,000 feet offshore.

Two general bottom communities were present in the area. The major one, a flat sand-bottom community, was encountered both north and south of the canyon mouth. The other, a kelp-bed community, was restricted to a narrow band paralleling the beach south of the proposed outfall in 25- to 40-foot depths, with scattered plants in water as shallow as 15 feet.

METHODS

We conducted field observations on 4 days, May 21 and 22 and June 19 and 20, 1962. During the first field day, we made a general survey, by vessel, north and south of Canyon de las Encinas, locating existing kelp beds and shoreside landmarks. Since our study called for enumerating and listing various animals and plants in the area, we chose four survey sites at or near the planned outfall (Figure 1).

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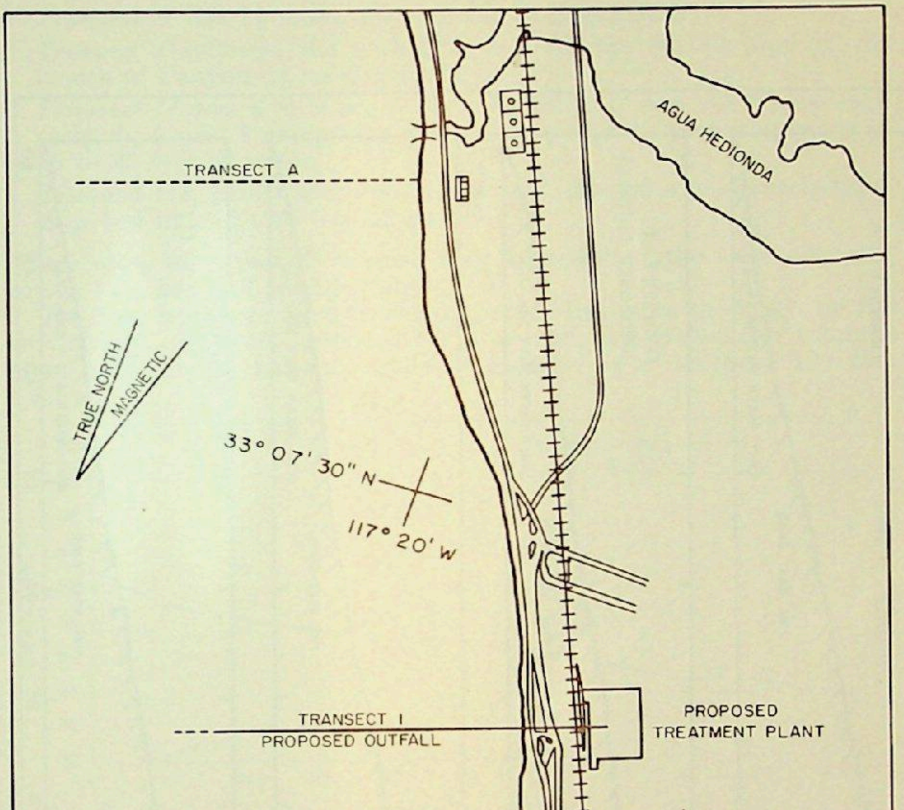

FIGURE 1. Area surveyed and transects.

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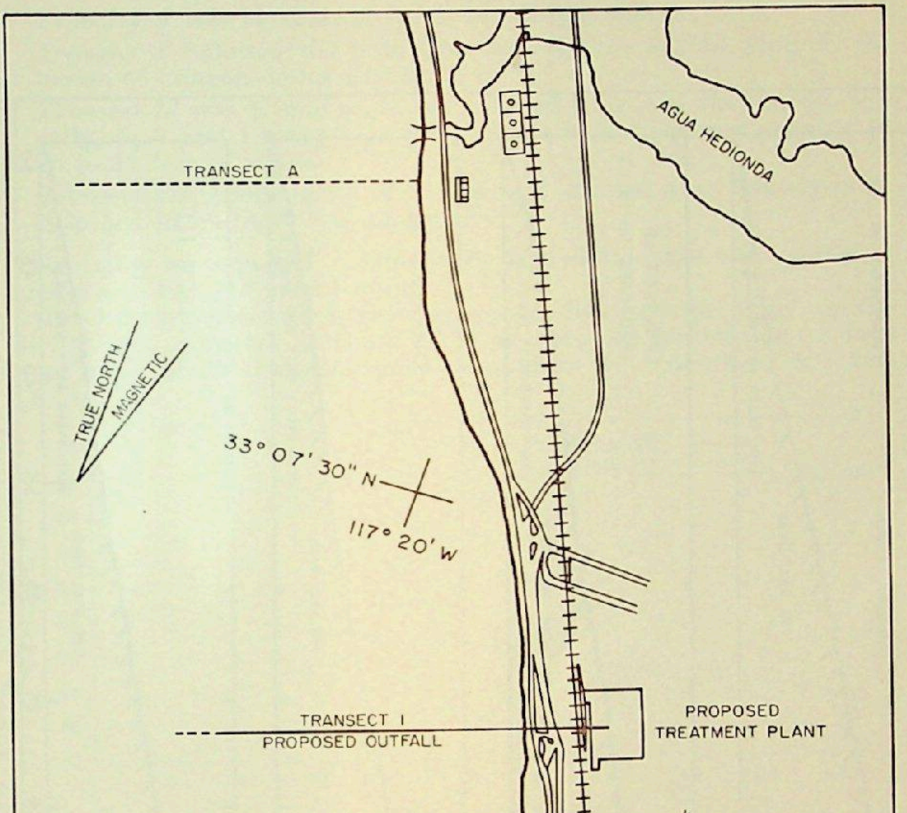

FIGURE 1. Area surveyed and transects.

TABLE 1

Composite Results of the Sand-bottom Surveys Conducted May 21, 22, and June 19, 1962, Canyon de las Encinas

		Biological observations			
Depth (feet)	Physical conditions and bottom type	Phylum	Scientific name	Common name	Number per 400 sq. ft. of bottom area
20	Hard-packed, light-gray sand with shallow ripple marks; 3- to 4-foot visibility.	Annelida (segmented worms)	*Diopatra ornata*	tube worm	15
		Mollusca (clams, snails, etc.)	*Olivella biplicata*	olive snail	8
			Moniliopsis incisa	tower snail	3
		Chordata (fishes)	*Urolophus halleri*	round stingray	15
			Xystreurys liolepis	fantail sole	2
40	Hard-packed, fine, gray sand; 1- to 2-inch ripple marks on the bottom; moderate to strong surge; turbid water; 3- to 4-foot visibility.	Annelida (segmented worms)	*Diopatra ornata*	tube worm	15
		Mollusca (clams, snails, etc.)	*Moniliopsis incisa*	tower snail	3
		Chordata (fish)	*Hypsopsetta guttulata*	diamond turbot	1
60	Gray, mud to silty-sand; ripple marks 3 to 4 inches apart; moderate surge; 4- to 5-foot visibility.	Coelenterata (anemones, etc.)	*Renilla kollikeri*	sea pansy	few*
			Edwardsiella sp.	sand anemone	few
		Annelida (segmented worms)		various worms	many**
		Mollusca (clams, snails, etc.)	*Terebra pedroana*	auger snail	1
			Cerithidea sp.	horn snail	1
			Nassarius fossatus	dog whelk	few
		Echinodermata (starfish, etc.)	*Astropecten californica*	sand star	3
			Lovenia cordiformis	heart urchin	2
		Chordata (fish)	*Citharichthys* sp.	sanddab	few
80	Olive-green, fine, silty-sand; ripple marks 6 to 8 inches apart; much debris; 10- to 12-foot visibility.	Coelenterata (anemones, etc.)	*Stylatula* sp.	sea pen	few
		Mollusca (clams, snails, etc.)	*Hermissenda crassicornis*	sea slug	many
			Octopus rubescens	octopus	1
			Trachycardium quadragenarium	spiny cockle	1
			Bursa californica	frog snail	4–5
		Echinodermata (starfish, etc.)	*Lovenia cordiformis*	heart urchin	few
			Astropecten californica	sand star	few
		Chordata (fishes & tunicates)	*Citharichthys* sp.	sanddab	few
			Paralabrax nebulifer	sand bass	1
			Styela montereyensis	sea squirt	few

TABLE 1—Continued

Composite Results of the Sand-bottom Surveys Conducted May 21, 22, and June 19, 1962, Canyon de las Encinas

		Biological observations			
Depth (feet)	Physical conditions and bottom type	Phylum	Scientific name	Common name	Number per 400 sq. ft. of bottom area
100	Gray mud; small 3- to 4-inch hills and valleys in the sediment; little water action; 14- to 16-foot visibility.	Coelenterata (anemones, etc.)	Ceriantheridae	tube anemone	1
		Porifera (sponges)	*Cliona celata*	burrowing sponge	many
		Annelida (segmented worms)	Polynoidea	scale worm	few
		Arthropoda (crabs, shrimp, etc.)	*Paguristes bakeri*	hermit crab	3
		Mollusca (clams, snails)	*Megasurcula carpenterianus*	Carpenter's tower snail	20
			Tresus sp.	gaper clam	3
		Echinodermata (starfish, etc.)	*Lytechinus anamesus*	white sea urchin	1
			Astropecten californica	sand star	2
		Chordata (fish)	*Citharichthys* sp.	sanddab	3

* few = less than 50.
** many = 50 to 500.

During May and June, we swam along these transects visually observing, collecting samples, and enumerating the animals and plants present. Planktonic animals and micro-organisms were not included. At each 20-foot depth interval, all animals and plants observed in a 400-square-foot sand-bottom area were listed (Table 1). At these points, we took water temperatures and measured water visibilities throughout the water column with a diver-held thermometer and Secchi disc (Table 5 and Figures 3a & 3b).

Where the transects bisected a kelp bed, we tallied all animals and plants along the entire section through the bed, a distance of approximately 500 linear feet for Transect II and 1,000 linear feet for Transect III (Tables 2, 3, 4, and Figure 2). Water temperatures and visibilities were also taken throughout the water column within these kelp areas (Table 5 and Figures 3a & 3b).

As biologist-divers of the California Department of Fish and Game, we employ SCUBA to remain underwater for prolonged periods. We record all underwater observations on plastic writing slates and later transcribe them into permanent logbooks.

Unrecognized animals and plants are collected routinely for laboratory identification using plastic jars, bags, net sacks, or spears. When possible, depending upon the specimen, they are identified fresh but some are frozen or fixed in alcohol or formalin.

Due to limited field time, we did not make complete species lists for the kelp-bed area. Instead, we compiled a representative index and sought potential indicator organisms.

The underwater time necessary to complete a survey depends upon such factors as water clarity, surge, depth, diversity of animal life, size of area, and experience and training of the biologist-divers. During this survey, we spent approximately 36 man-hours underwater. In all diving we utilize the ''buddy'' system wherein no diving is done unless two or more individuals accompany each other.

RESULTS

The sand-bottom areas sloped gently seaward, grading from light-gray sand near the beach to gray-green silty-mud at a depth of 100 feet. The bottom community, typical of flat sandy areas, contained relatively few animals and no plants (Table 1). Sand stars, heart urchins, and small sanddabs were most common.

FIGURE 4. The barren sand bottom encountered at 80 feet along Transect I, June 19, 1962. The white object (center) is the shell of a dead olive snail about 1 inch long. *Photograph by Charles H. Turner.*

By contrast, the bottom in the kelp-bed areas consisted of low, 8- to 10-inch sandstone and mudstone shelves interspaced with hard-packed gray sand. Numerous fishes swam throughout the water column while other animals crawled over the bottom and burrowed into or attached to the substrate or each other, giving the areas a fertile appearance. Approximately 100 animal species were readily observed (Tables 3 and 4).

Although the kelp bed was not extensive and only moderately thick, the plants appeared healthy. Surf grass (a flowering plant) and ten kinds of algae were observed (Table 2).

Water visibility ranged from 0 to 10 feet in May due to storm-caused turbulence. In June, it varied from 3 to 16 feet. During both survey periods, visibility was a function of depth and temperature (Figures 3a & 3b, Table 5). In June, the surface waters down to 15 feet were nearly opaque because of red-tide organisms, presumably *Gonyaulax* spp.

Water temperatures varied with depth and survey period. In May, the high was 56.5°F. at the surface and the low was 52.7°F. at 100 feet. In June we recorded 62.6°F. at the surface and 51.1°F. at 100 feet (Figures 3a & 3b, Table 5).

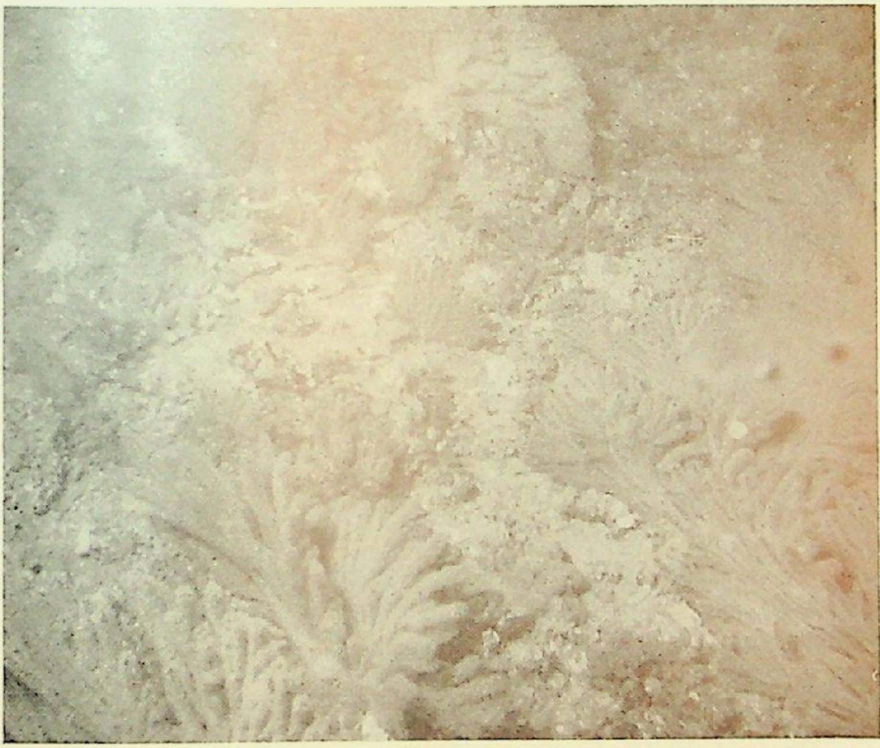

FIGURE 5. A section of the kelp bed area, Transect III, illustrating the numerous gorgonians. *Photograph by Charles H. Turner.*

RECOMMENDATIONS

We recommend continued surveillance of this area for at least 3 to 5 years after the outfall is put into operation. By employing biologist-divers to survey periodically (at least quarterly) the areas covered in this first study, changes brought about by waste discharges from the outfall can be recorded. Particular attention should be given to the kelp-bed areas since certain animals and plants may be more seriously affected than others by domestic and industrial wastes. By studying relative changes in the concentrations of these plants and animals, pollution-indicating species should be found for this area.

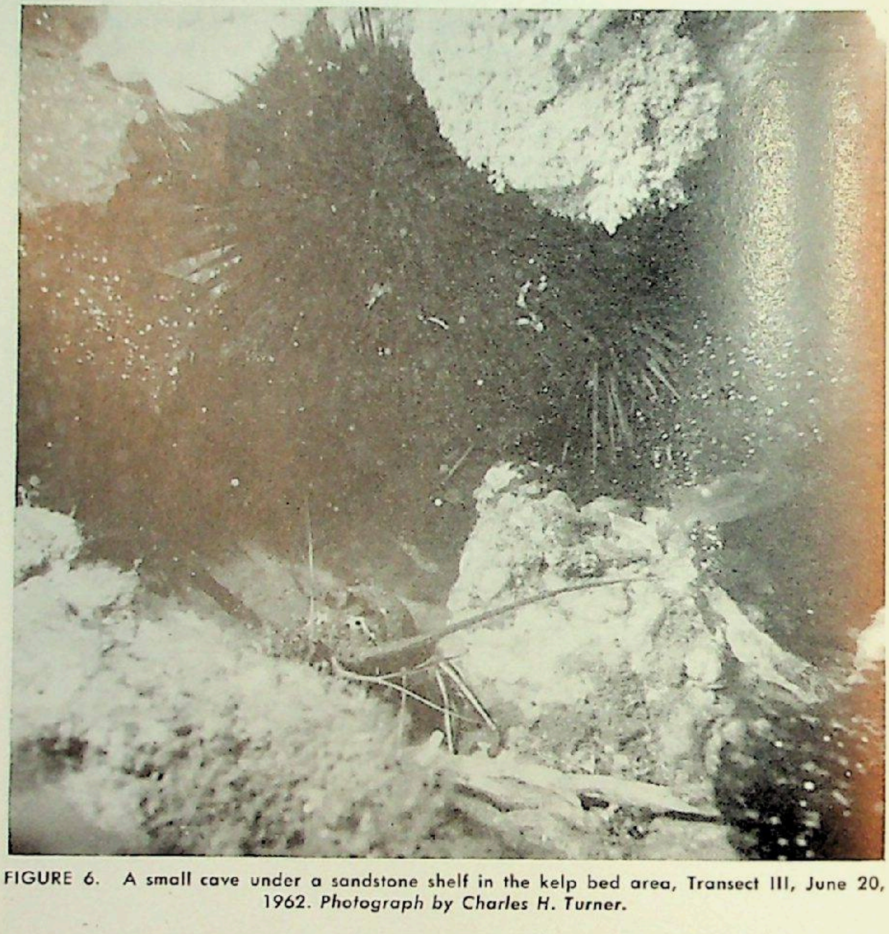

FIGURE 6. A small cave under a sandstone shelf in the kelp bed area, Transect III, June 20, 1962. *Photograph by Charles H. Turner.*

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We are particularly indebted to Leonard Burtman, San Diego Regional Water Pollution Control Board, for help in defining the study area; to the United States Marine Corps personnel at the Camp Del Mar Boat Basin for use of their launching facilities; to Patricia Powell for helping locate references; and to the secretarial staff at the California State Fisheries Laboratory, Terminal Island, for typing the manuscript.

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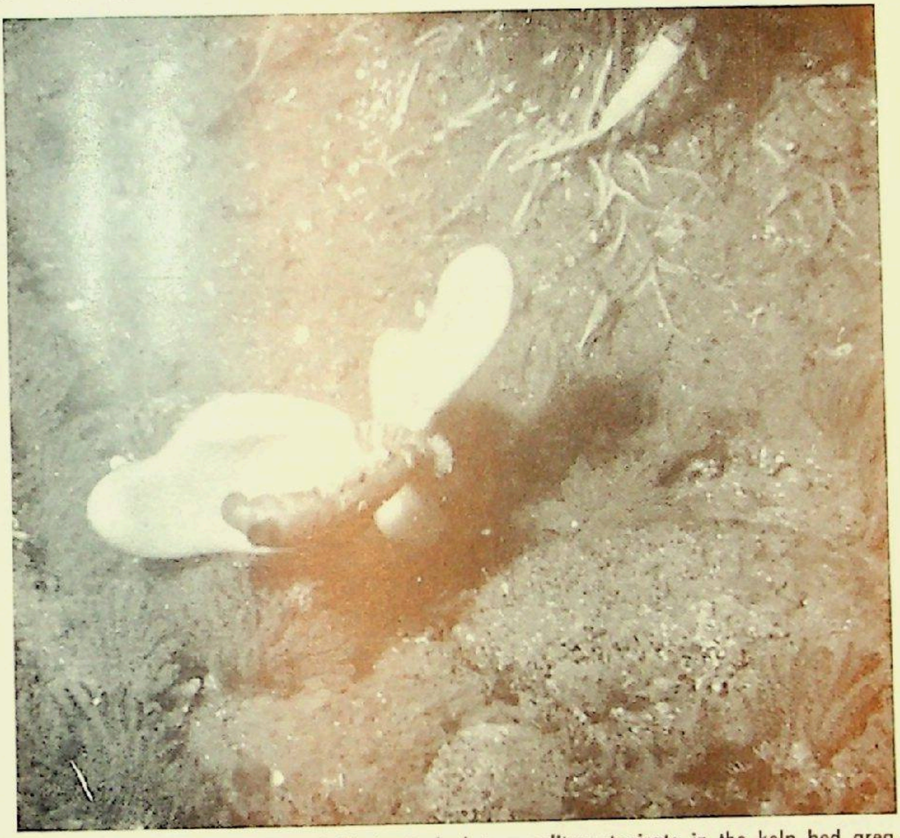

FIGURE 7. A colonial tunicate (white) attached to a solitary tunicate in the kelp bed area, Transect III, in 35 feet of water. *Photograph by Charles H. Turner.*

TABLE 2

Algae Observed in the Kelp Bed Areas of Canyon de las Encinas June 19 and 20, 1962

Group	Scientific name	Remarks
Phaeophyta (brown algae)	*Macrocystis pyrifera*	A large brown alga whose fronds trail back on the surface forming a canopy below. The dominant alga (biomass) of the kelp-bed area. It provides food, shelter and attachment space.
	Laminaria farlowii	A moderate-size brown alga, consisting of one rather wide blade that extends up from the substrate a yard or more. Many small plants were present. Observed only in Transect III.
	Eisenia arborea	A brown alga 1 to 2 feet high, common throughout this kelp-bed area.
	Egregia laevigata	One of the larger brown algas. Commonly called "feather boa." Moderately common in this kelp bed.
Rhodophyta (red algae)	*Lithothamnion* sp.	A calcareous encrusting alga.
	Corallina sp.	A calcareous alga.
	Lithothrix sp.	A calcareous alga.
	Bossea sp.	A calcareous alga.
	Rhodymenia spp.	Small red algae 1 to 2 inches high. At least 2 species were present.
	Antithamnion sp.	A small, delicate, hair-like red alga.

In addition to these 10 kinds of algae, surf grass *Phyllospadix torreyi*, (a flowering plant) was growing on the sandstone substrate.

TABLE 3

Fishes Observed in the Kelp Bed Areas of Canyon de las Encinas June 19 and 20, 1962

		Transect II 500 linear feet		Transect III 1,000 linear feet	
Scientific name	Common name	Number observed	Estimated lengths (inches)	Number observed	Estimated lengths (inches)
Urolophus halleri	round stingray			3	12–16
Citharichthys sp.	sanddab	40	1–6	20	3–5
Pleuronichthys decurrens	curlfin turbot			2	8–10
Pleuronichthys verticalis	hornyhead turbot	1	10	2	8–10
Hypsopsetta guttulata	diamond turbot			3	8–10
Paralabrax clathratus	kelp bass	35	6–12	500	8–18
Paralabrax nebulifer	sand bass			100	8–20
Atherinops affinis	top smelt			1,000	5–8
Xenistius californiensis	salema			500–1,000	5–6
Anisotremus davidsoni	sargo			50	7–11
Girella nigricans	opaleye			200	6–12
Brachyistius frenatus	kelp perch			300	4–6
Embiotoca jacksoni	black perch	10	6–10	1,000	6–10
Hyperprosopon argenteum	walleye surfperch	50	3–6	200	4–6
Hypsurus caryi	rainbow seaperch	25	5–9	300	4–7
Phanerodon furcatus	white seaperch			500	4–7
Rhacochilus toxotes	rubberlip perch	10	8–12	200	5–12
Rhacochilus vacca	pile perch	10	8–12	200	4–7
Chromis punctipinnis	blacksmith			25	5–9
Halichoeres semicinctus	rock wrasse			15	6–8
Oxyjulis californica	senorita			50	8–11
Pimelometopon pulchrum	California sheephead	20	10–16	75	8–16
Scorpaena guttata	sculpin	1	6	50	5–12
Sebastodes atrovirens	kelp rockfish			1	10
Gibbonsia sp.	kelpfish			1	5

TABLE 4

Invertebrates and Tunicates Observed in the Kelp Bed Areas of Canyon de las Encinas, June 19 and 20, 1962

Phylum	Scientific name	Common name	Number observed	
			Transect II 500 linear feet	Transect III 1,000 linear feet
Porifera (sponges)	*Leucetta losangelensis*	white calcareous sponge	many	many**
	Cliona celata	boring sponge	many	many
	Tedania topsenti	sponge	10	--
Coelenterata	*Muricea fruticosa*	rust gorgonian	numerous, averaging 15/sq. yd.	numerous, averaging 15/sq. yd.
	Anthopleura xanthogrammica	green anemone	many	many
	Edwardsiella sp.	burrowing anemone	many	many
	Astrangia sp.	cup coral	15	many
	Epiactis prolifera	prolific anemone	1	many
	Sertularella sp.	hydroid	numerous	numerous***
	Pachycerianthus torreyi	tube anemone	--	few*
	Tealia lophotensis	anemone	--	few
	Renilla kollikeri	sea pansy	--	few
Nemertea (ribbon worms)	*Lineus* sp.	nemertean worm	many	--
Annelida (segmented worms)	*Spirorbis* sp.	calcareous tube worm	--	numerous
	Serpula vermicularis	calcareous tube worm	many	--
	Chaetopterus variopedatus	parchment tube worm	many	numerous
	Salmacina dysteri	colonial tube worm	--	many colonies
Arthropoda (crabs, etc.)	*Loxorhynchus grandis*	spider crab	few	few
	Loxorhynchus crispatus	masking crab	few	few
	Pugettia richii	masking crab	--	1
	Pugettia dalli	masking crab	--	4
	Lophopanopeus leucomanus	small crab	--	1
	Opisthopus transversus	pea crab	few	--
	Panulirus interruptus	spiny lobster	--	1
	Mysidacea	mysids	numerous	--
Mollusca (clams, snails, etc.)	*Astraea undosa*	wavy top shell	1/sq. yd.	few
	Conus californicus	California cone	many	many
	Jaton festivus	festive murex	1/sq. yd.	few
	Serpulorbis squamigerus	worm tube snail	few	many
	Olivella biplicata	olive snail	--	few
	Kelletia kelletii	Kellet's whelk	--	many
	Cypraea spadicea	chestnut cowry	--	few
	Moniliopsis incisa	tower snail	--	many
	Polinices lewisii	moon snail	--	1
	Calliostoma tricolor	top shell	--	many
	Burchia redondoensis	black snail	--	few
	Nassarius perpinguis	fat nassa	--	many
	Anisodoris nobilis	sea lemon	--	few
	Dendrodoris albopunctata	sea slug	few	few
	Diaulula sandiegensis	sea slug	--	few
	Lima hemphilli	file clam	--	few
	Mytilus edulis	bay mussel	few	--
	Lithophaga subula	date mussel	10/sq. yd.	numerous
	Parapholas californica	scale-sided piddock	10/sq. yd.	numerous
	Chaceia ovoidea	wart-necked piddock	10/sq. yd.	numerous
	Chlamys latiaurata	kelp scallop	many	many
	Hinnites multirugosus	rock scallop	--	2
	Crepidula onyx	onyx slipper shell	--	many

TABLE 4—Continued

Invertebrates and Tunicates Observed in the Kelp Bed Areas of Canyon de las Encinas, June 19 and 20, 1962

Phylum	Scientific name	Common name	Number observed	
			Transect II 500 linear feet	Transect III 1,000 linear feet
Bryozoa (moss animals)	*Filicrisia* sp.	moss animal	many	many
	Membranipora membranacea	moss animal	many on kelp	many on kelp
	Thalamoporella californica	moss animal	scattered patches	scattered patches
	Phidelophora pacifica	moss animal	--	few colonies
	Diaperoecia californica	moss animal	--	numerous
	Bugula sp.	moss animal	--	numerous
Echinodermata (starfish, etc.)	*Ophiothrix spiculata*	brittle star	numerous	numerous
	Pisaster ochraceus	ochre starfish	many	few
	Pisaster giganteus	common starfish	--	few
	Pisaster brevispinis	short spined starfish	--	1
	Astropecten californica	sand star	--	few
	Lytechinus anamesus	white sea urchin	few	few
	Dendraster excentricus	sand dollar	few	--
	Stronglyocentrotus purpuratus	purple sea urchin	--	35
	Stronglyocentrotus franciscanus	giant red urchin	--	2
	Parastichopus parvimensis	sea cucumber	--	few
	Thyonepsolus nutriens	orange-red sea cucumber	--	1
Chordata (tunicates)	*Metandrocarpa dura*	tunicate	--	few
	Euherdmania claviformis	tunicate	few	--
	Pyura haustor	tunicate	few	--
	Cystodytes lobatus	tunicate	--	few colonies
	Didemnum carnulentum	tunicate	few	--
	Styela montereyensis	tunicate	many	many
	Trididemnum opacum	tunicate	few	--

* few = less than 50.
** many = 50-500.
*** numerous = over 500.

TABLE 5

Temperatures and Visibilities Recorded During the Canyon de las Encinas Survey

	May 21 and 22, 1962*			June 19 and 20, 1962*		
Depth (in feet)	Temp. °F.	Visibility (in feet)	Remarks	Temp. °F.	Visibility (in feet)	Remarks
0	56.5	0	turbulent	62.6	3–4	red tide
10	55.4	0	turbulent	61.0	3–4	red tide
20	55.0	1	heavy surge	59.4	3–4	murky water
30	54.7	1	heavy surge	54.0	3–4	murky water
40	54.5	1	heavy surge	52.7	4–5	clearing
50	54.3	1	moderate surge	52.0	6–8	clearing
60	54.0	3	moderate surge	51.8	8–10	clearing
70	53.6	3	moderate surge	51.6	10–12	slight surge
80	53.1	6	moderate surge	51.4	10–12	slight surge
90	53.1	10	light surge	51.1	10–12	quiet
100	52.7	10	light surge	51.1	14–16	quiet

* Temperature readings for the two-day periods were so similar they were grouped.

A NEW SPECIES OF EAGLE RAY, *MYLIOBATIS LONGIROSTRIS*, FROM BAJA CALIFORNIA, MEXICO[1]

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On August 11, 1963, the crew of the California Department of Fish and Game research vessel *Alaska* collected a number of fishes in a surface tow of their midwater-trawl net. The tow was made in 84 to 102 feet of water in Magdalena Bay, Baja California, Mexico, at station 63A5-9T (lat. 24° 38.5′ N, long. 112° 06.5′ W to lat. 24° 37.0′ N, long. 112° 04.0′ W). The net, with a 35- to 50-foot opening, was towed with only 80 fathoms of cable out, so all of the fishes were captured in the upper 50 feet of water. The catch consisted of four hammerhead sharks, *Sphryna zygaena* (Linnaeus); four requiem sharks, *Carcharhinus* sp.; two bullseye puffers, *Sphaeroides annulatus* (Jenyns); two thread herring, *Opisthonema* sp.; two sierra *Scomberomorus sierra* Jordan and Starks; a Pacific yellowtail jack, *Chloroscombrus orqueta* Jordan and Gilbert, and an eagle ray.

When we first examined this ray we thought it was identical to the Atlantic *Myliobatis freminvillii* Lesueur, and as such, represented a remarkable range extension for that species. A closer examination has convinced us that this specimen lies outside the range of variation shown by *M. freminvillii* and, therefore, represents a hitherto undescribed eagle ray.

Although a fair amount of confusion has existed concerning what genera belong in the Myliobatidae, the generic separations given by Bigelow and Schroeder (1953) have cleared up this problem satisfactorily, and are followed here. The seven teeth per row in each jaw of our eagle ray separate it from *Actobatus;* its caudal spine eliminates *Actomylcus,* and *Pteromylaeus* was eliminated by an X-ray which shows the rostral portion of the pectorals connected with the main portion of this fin by a continuous series of radial cartilages. We follow Bigelow and Schroeder (1953) in not considering *Holorhinus* a valid genus.

Myliobatis longirostris, new species

(Figures 1-3)

Holotype: LACM 3622, a mature male, from station 63A5-9T of the California Department of Fish and Game research vessel *Alaska* in Magdalena Bay, Baja California, Mexico. The specimen has been deposited in the ichthyological collections of the Los Angeles County Museum.

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[1] Submitted for publication February 1964.

Diagnosis: A *Myliobatis* with a pointed, shovel-shaped snout, 19 medial tubercles, and strongly-bowed upper teeth. There are two caudal spines, the anteriormost lying directly behind the dorsal fin.

Description: Disc lozenge-shaped; "wing" tips pointed and narrow as in *M. freminvillii;* the total length (including the tail) is about twice the total width. There are two caudal spines (the inner one is broken in the type); the spine tip (Figure 3A) is finely serrate; the side barbs are narrow and do not form a continuous outer edge; the anterior spine lies directly (4 mm) behind the dorsal fin (Figure 3B). The distance from the dorsal fin to the edge of the pelvics is less than one-half the length of the dorsal fin; the height of the dorsal fin is about one-half its total length. The skin is naked except for 19 tubercles or bucklers in the midline of the back about one-half way between the head and the tail; the bucklers are smooth and rounded. A rounded tubercle is present above each eye (Figure 3C). Each jaw contains seven rows of teeth, with three laterals, one medial, and three laterals in each row; the upper medial bows strongly anteriorly at each end (Figure 3D). The flap above the jaw is fringed with about 16 projections on one side and 12 on the other. The dorsal surface of

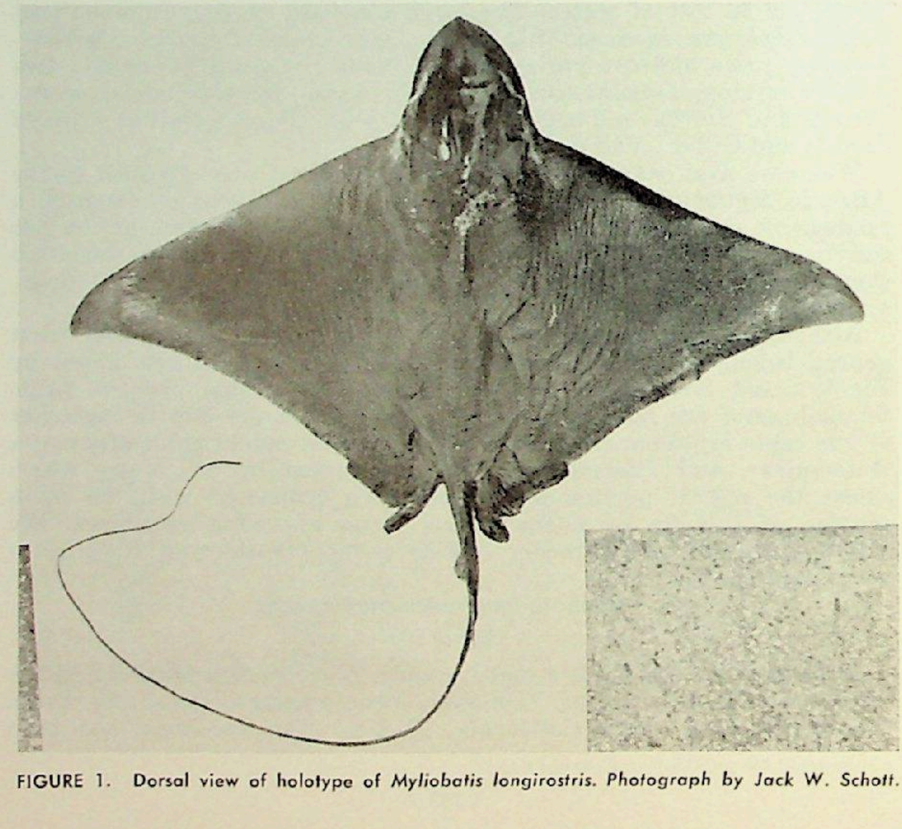

FIGURE 1. Dorsal view of holotype of *Myliobatis longirostris*. Photograph by Jack W. Schott.

this ray is dark reddish-brown. The undersurface is dusky white, grading to black on the edge of the rostrum, wing tips, pelvic fins, and claspers. The teeth are cream-colored. There are no spines nor hooks on the claspers.

According to Garman (1913), Fowler (1941), Bigelow and Schroeder (1953) and de Buen (1959), the genus *Myliobatis* includes 12 recognized species: *M. aquila* (Linnaeus), *M. freminvillii* Lesueur, *M. goodei* Garman, *M. californicus* Gill, *M. peruvianus* Garman, *M. chilensis* Philippi, *M. tobijei* (Bleeker), *M. tenuicaudatus* (Hector), *M. australis* (Macleay), *M. cervus* (J. L. B. Smith), *M. hamlyni* (Ogilby), and *M. rhombus* Basilewsky. *M. rhombus* is said to lack a dorsal fin. A short, broad, rounded snout quite different from our eagle ray is known in *M. californicus, M. peruvianus, M. chilensis, M. goodei, M. aquila, M. cervus, M. hamlyni, M. australis* and *M. tenuicaudatus.* An elongate, pointed snout, closer to *M. longirostris,* occurs in *M. freminvillii* and *M. tobijei. M. tobijei* can be separated from both *M. freminvillii* and *M. longirostris* because it has rounded pectoral tips and its dorsal fin originates 1.5 times its length behind the edge of the pelvic fin.

Myliobatis longirostris lies closest to *M. freminvillii* but can be separated from the latter by several characters. The rostrum in *M. longirostris* is spade-shaped, more elongate, and more pointed at its tip.

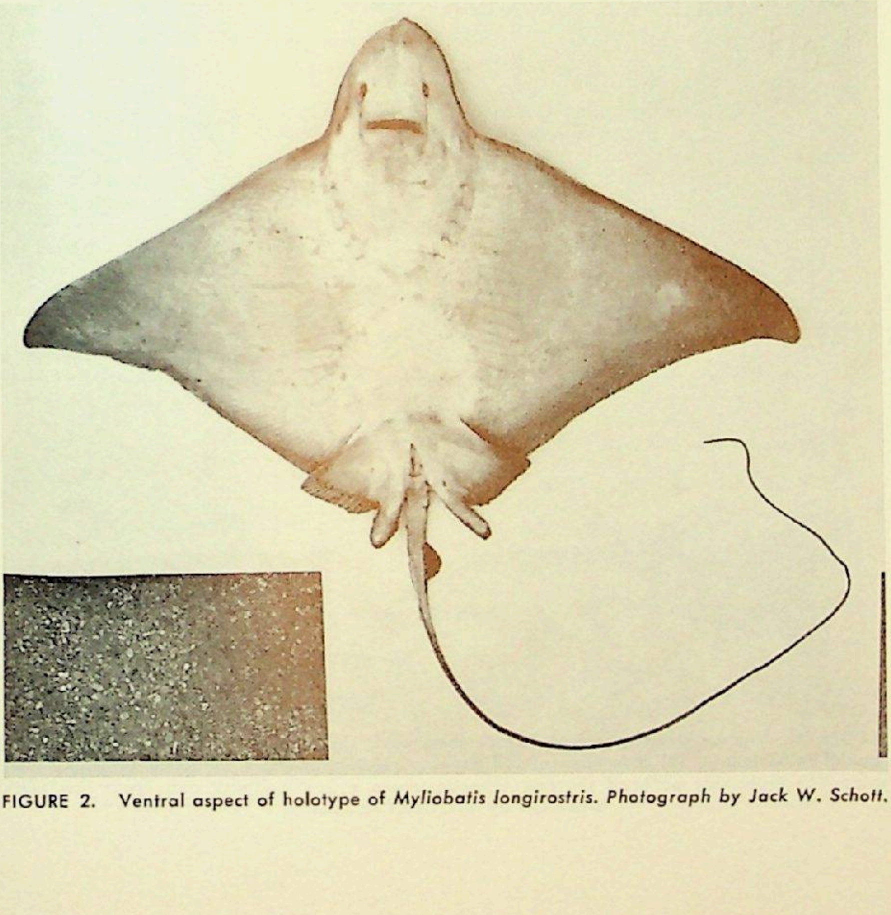

FIGURE 2. Ventral aspect of holotype of *Myliobatis longirostris*. *Photograph by Jack W. Schott.*

There are 19 smooth tubercles in the midline of *M. longirostris* in contrast to the seven or eight tubercles reported by Bigelow and Schroeder (1953) for *M. freminvillii*. In *M. longirostris* the origin of the anterior caudal spine is directly (4 mm) behind the dorsal fin. The teeth of *M. longirostris* are cream-colored (green in *M. freminvillii*), and the upper medial teeth curve in a strong bow with the ends pointed anteriorly, more so than in any *M. freminvillii* jaw of comparable size that we have examined.

Since *M. longirostris* is so similar to *M. freminvillii* we feel that both may have had a common origin in a single species which occurred originally in both the Atlantic and Pacific. The two present populations became separated in the late Pliocene when the continuous land connection between North and South America emerged (Simpson, 1953). The differences between these two species may have come about through their subsequent isolation and evolution.

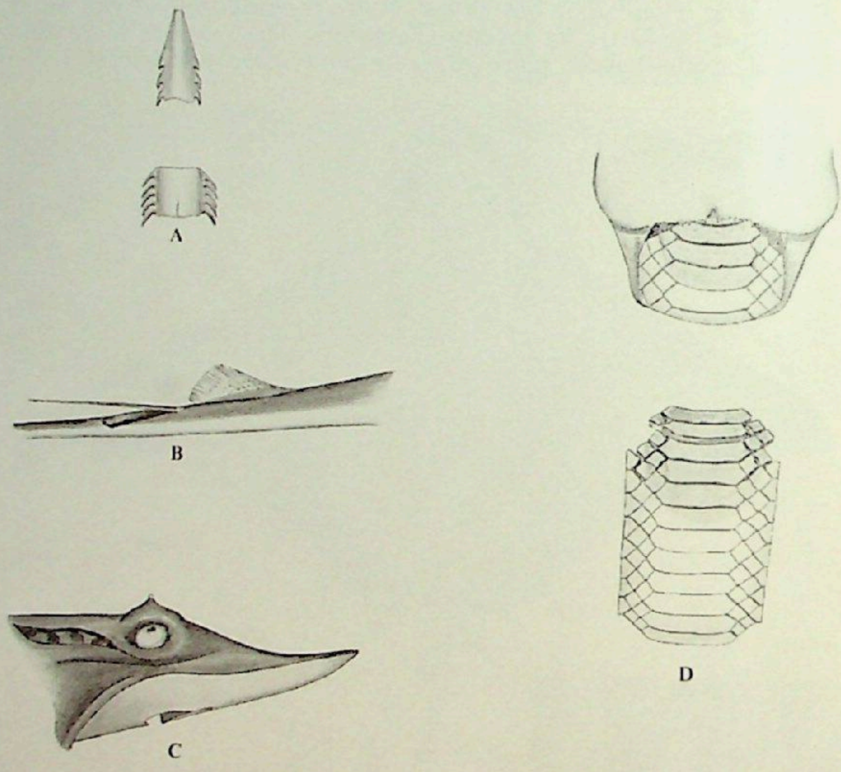

FIGURE 3. Various structures of *Myliobatis longirostris* (holotype): (A) Tip and mid-section of caudal spine (sting); (B) Side view of tail showing relative positions of dorsal fin and caudal spine; (C) Right side of head showing tubercle above eye; (D) Upper and lower jaw teeth. *Drawings by Mrs. Pearl Handback.*

During the same cruise of the *Alaska* (63A5), 13 additional eagle rays were captured that probably were the same species. The biologists aboard the vessel listed them in their station logs as "duck-billed eagle rays," the same designation they gave the Magdalena Bay specimen. Eleven of these were captured in surface tows of the midwater trawl at Ballenas Bay, Baja California, and the other two in a surface tow at San Cristobal Bay, Baja California; unfortunately, because they appeared to be fairly common constituents of the midwater-trawl catches, only the first (Magdalena Bay) specimen was saved. Based upon these captures, the minimal range of *M. longirostris* extends from San Cristobal Bay (lat. 27° 18′ N) south to Magdalena Bay, Baja California. Apparently the species occurs mostly in the upper water column, at or near the surface, because a great deal of bottom trawling throughout much of this area during the past several decades has failed to yield a single recorded specimen.

Fossil myliobatid teeth are known from both the Atlantic and Pacific coasts. In the Atlantic and Gulf coast fossil beds they occur from the Eocene to the Recent. In California they are known from the Eocene to the Recent. It has never been demonstrated that *Myliobatis* teeth can be used to separate modern species, and any interpretation of fossil forms is quite risky.

The specific name is based on a combination of two Latin words, *longus* and *rostrum*, meaning long-snouted.

TABLE 1

Proportional Measurements in Percent of Extreme Disc Breadth for Holotype of *Myliobatis longirostris*

Measurement	*Proportion*
Extreme disc breadth (633 mm)	100.0
Vertical disc length: right side	48.6
: left side	49.2
Snout length: in front of orbits	12.3
: from center of mouth flap	16.1
Orbit length	2.2
Interorbital width	14.8
Mouth breadth	6.7
Internarial distance	6.6
Length of gill opening: 1st right	2.5
: 2nd right	2.8
: 3rd right	2.6
: 4th right	2.3
: 5th right	1.6
: 1st left	2.5
: 2nd left	2.8
: 3rd left	2.5
: 4th left	2.5
: 5th left	1.6
Dorsal fin: vertical height	2.8
: length of base	6.0
Pelvic fin: length of outer margin	7.7
Snout to pectoral fin axis	58.6
Snout to dorsal fin	72.7
Spiracle: length	6.3
: distance between	15.1
Nostril to tip of snout	10.7
Clasper length	6.6
Distance of dorsal fin behind pelvic fin	1.6
Distance from pectoral axil to pectoral axil	11.2

ACKNOWLEDGMENTS

The drawings for this paper are by Mrs. Pearl Handback, Los Angeles County Museum, and the photographs by Jack W. Schott, California Department of Fish and Game. Kenneth F. Mais and John L. Baxter, marine biologists aboard the *Alaska,* were responsible for saving this eagle ray. Stewart Springer, U. S. Fish and Wildlife Service, was particularly helpful in giving an opinion on the distinctness of this fish.

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FIRST RECORDS FOR THE BIGEYE THRESHER *(ALOPIAS SUPERCILIOSUS)* AND SLENDER TUNA *(ALLOTHUNNUS FALLAI)* FROM CALIFORNIA, WITH NOTES ON EASTERN PACIFIC SCOMBRID OTOLITHS[1]

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During 1963, two bigeye threshers and a slender tuna were captured in California marine waters for the first time. Most first-timers (fishes) taken locally during the past 10 years (e.g., *Hemiramphus saltator, Pentaceros richardsoni, Reinhardtius hippoglossoides, Nematistius pectoralis, Seriola colburni, Trachinotus rhodopus, Trachinotus paitensis, Vomer declivifrons, Remilegia australis, Scomberomorus sierra, Auxis thazard, Pallasina barbata, Kathetostoma averruncus, Dormitator latifrons,* etc.) have represented northern (or southern) range extensions for southern (or northern) species, but the bigeye thresher and slender tuna represented "firsts" for the eastern Pacific Ocean as well as for California. Only a few other fishes have shared similar honors since 1950 (i.e., *Carcharias ferox, Tetrapturus angustirostris, Taractes longipinnis,* etc.).

BIGEYE THRESHER, *ALOPIAS SUPERCILIOSUS* (LOWE, 1840)

On July 23, 1963, N. H. Delaney, of Delaney Bros. Sea Food Co. Inc., Newport Beach, called California State Fisheries Laboratory to report having received from a gill-net fisherman a large shark he did not recognize. The fisherman, Gene Hachez of Costa Mesa, had caught the shark the previous night while his nets were set on the bottom in 85 fathoms near the head of a submarine canyon off San Clemente (city). On the phone, Mr. Delaney said the shark resembled a common thresher, *Alopias vulpinus,* but differed from it by having an exceedingly large eye, larger and fewer teeth, and peculiar grooves running posteriorly along each side of its head above and behind its eye. These characters were sufficient for us to recognize the shark as a bigeye thresher, so we asked Mr. Delaney to save it for us.

It turned out to be a male, 12 feet 4 inches long, weighing 361 pounds (Figure 1, Table 1). Mr. Hachez reported that it had been all alone near the center of his net where its struggles had wreaked havoc, entangling meshes for several yards in all directions. The only other fishes in that set were a few soupfin sharks, *Galeorhinus zyopterus,* near the net's extreme ends, at a considerable distance from the thresher. The thresher's stomach contained six partially-digested hake, *Merluccius productus,* weighing 8 pounds.

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The *Alopias* species-key in Bigelow and Schroeder (1948) is based upon several immature *A. superciliosus* and their principal character for separating *superciliosus* and *profundus* from *pelagicus, vulpinus,* and *caudatus* ("Rear tip of 1st dorsal extends at least as far as origin of pelvics, or even overlaps the latter.") would not work with our specimen. On our shark, the rear tip of the first dorsal failed to reach to vertically above the pelvic origin by several centimeters. Such variation is to be expected, and will continue to occur as additional material representing all sizes in both sexes becomes available (they reportedly reach 18 feet). In most other respects, our thresher fitted Bigelow and Schroeder's description of *A. superciliosus* quite well (Tables 1 and 2).

Three weeks after catching the San Clemente *A. superciliosus,* Mr. Hachez netted a female in 60 fathoms some 3½ to 4 miles west of the Mission Bay Jetty (near San Diego, California). This specimen, taken on August 12, was 11 feet 11 inches (3,645 mm) long and weighed 310 pounds. It was turned over to Scripps Institution of Oceanography (SIO 63-1087-5A) where is was measured and preserved before being sent to the U. S. National Museum (USNM 197700).

This species, first reported in 1840 from Madeira, was not seen again until 1941 when a 12-footer was caught off Florida (Bigelow and Schroeder, 1948). Between 1941 and 1948, several additional specimens, including an 18-footer, were taken off Cuba and Florida. Quite recently, three bigeye threshers were captured in the Atlantic on longline gear. On January 20, 1962, a female (approximately 300 cm TL) was caught on a 310-hook set at lat. 25° 40′ N., long. 77° 15′ W. Other fishes taken in the same set were one dolphin (*Coryphaena hippurus*), one yellowfin

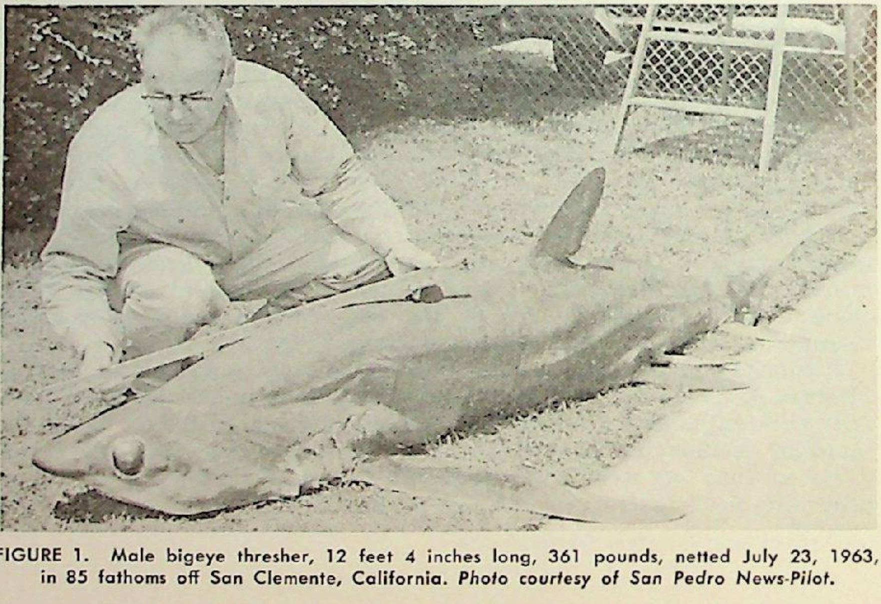

FIGURE 1. Male bigeye thresher, 12 feet 4 inches long, 361 pounds, netted July 23, 1963, in 85 fathoms off San Clemente, California. *Photo courtesy of San Pedro News-Pilot.*

tuna (*Thunnus albacares*), one bigeye tuna (*Thunnus obesus*), and one dusky shark (*Carcharhinus obscurus*) (Martin R. Bartlett, pers. commun.). An adult male, 339 cm long weighing an estimated 300 pounds, was caught on a 150-hook set November 12, 1962, in Hydrographer Canyon (lat. 39° 57′ N., long. 68° 43′ W.). Three yellowfin tuna

TABLE 1

Measurements of Body Parts and Proportions in Length Without Caudal (parts per mille) of *Alopias superciliosus* from San Clemente, California

	Measurement (mm)	*Proportion*
Total length	3810	1.832
Length without caudal (to pit)	2080	--
Trunk width over pectoral origins	345	.166
Trunk depth over pectoral origins	455	.219
Head length	640	.308
Head width at angles of mouth	220	.106
Interorbital width	115	.055
Head width at outer end of nostrils	168	.081
Mouth width	150	.072
Mouth length (lower jaw)	103	.050
Fleshy orbit diameter, horizontal	60	.029
vertical	93	.045
Preoral length	159	.076
Prenarial length	118	.057
Nostril length	16	.008
Internarial distance (least)	54	.026
Length 1st gill slit	118	.057
Length 2nd gill slit	121	.058
Length 3rd gill slit	118	.057
Length 4th gill slit	116	.056
Length 5th gill slit	113	.054
Origin pectoral to base 1st gill slit	122	.059
Height 1st dorsal (perpendicular)	317	.152
Length 1st dorsal base *	223	.107
Height posterior margin 1st dorsal	274	.132
Length free rear tip 1st dorsal *	52	.025
Height 2nd dorsal (perpendicular)	29	.014
Length 2nd dorsal base *	39	.019
Length free rear tip 2nd dorsal *	34	.016
Height anal (perpendicular)	46	.022
Length anal base	40	.019
Length free rear tip anal *	42	.020
Length pelvic	322	.155
Length pelvic base	288	.138
Pelvic origin to anal origin	468	.225
Pelvic origin to pectoral origin	940	.452
Length anterior margin pectoral	673	.324
Length posterior margin pectoral	122	.059
Length distal margin pectoral	675	.325
Length upper caudal lobe	1745	.839
Length lower caudal lobe	260	.125
Tip of snout to 1st dorsal origin	1247	.600
Tip of snout to 2nd dorsal origin	1910	.918
Tip of snout—anal origin	1540	.740
Tip of snout—pelvic origin	1980	.952
Tip of snout—pectoral origin	580	.279
Origin 1st dorsal to origin 2nd dorsal	663	.319
Origin 2nd dorsal to upper precaudal pit	211	.101
Origin anal to lower precaudal pit	116	.056
Origin pelvic to clasper tip	485	.233

* Fin torn.

and three bigeye tuna were taken in the same set. The stomach of this shark contained the remains of two squids and five longnose lancetfish, *Alepisaurus ferox* (John G. Casey, pers. commun.). The third bigeye was a 12-foot male taken in a 500-hook set during the night of February 26-27, 1963, between lat. 35° 45′ N., long. 74° 35′ W. and lat. 35° 39′ N., long. 74° 27′ W. Hooked at the same time were 16 swordfish (*Xiphias gladius*), 7 bigeye tuna, 1 yellowfin tuna, 5 blue sharks (*Prionace glauca*), 3 mako sharks (*Isurus oxyrinchus*), and 1 silky shark (*Carcharhinus floridanus*) (Martin R. Bartlett pers. commun.).

The heads of all these recently-captured bigeye threshers (Atlantic and Pacific) were grooved on each side from above the eye to above the anterior-most gill slits. The grooves are joined where they originate on the midline above the eye, giving the shark a "helmeted" look (Figure 2). Their function is unknown, but they may help in streamlining and thus assist the shark to maneuver rapidly while pursuing food at the depths where it obviously lives. Whatever their function, these grooves do serve as an additional external character (if one is needed) for distinguishing *Alopias superciliosus*. Similar grooves occur on the heads and napes of louvars *(Luvarus imperialis)* and escolars *(Lepidocybium flavobrunneum)*, both fast-swimming inhabitants of bathypelagic habitats.

Our shark has been deposited in the California Academy of Sciences collection (CAS 27072).

TABLE 2

Tooth Measurements (in mm) of San Clemente, California, *Alopias superciliosus*

Measurements Taken on Left Side, Front to Rear

Tooth Formula $\frac{9 + 10}{10 + 10}$

Tooth number	*Width of base*	*Height (perpendicular from center)*
	Upper Jaw	
1	10.0	12.1
2	12.0 *	11.3
		13.0 †
3	13.1	13.0
4	13.5	11.5
5	14.3	10.0
6	13.2	10.0
7	12.4	8.8
8	11.6	6.0
9	broken	broken
	Lower Jaw	
1	11	8.0 ‡
2	12.5	9.8 †
3	12.0 †	9.5 †
4	12.0 †	9.0 †
5	12.5 †	8.8 †
6	10.6	7.0
7	10.2	6.4
8	unable to measure	
9	unable to measure	
10	unable to measure	

* Tip broken.
† 2nd row tooth.
‡ 3rd row tooth.

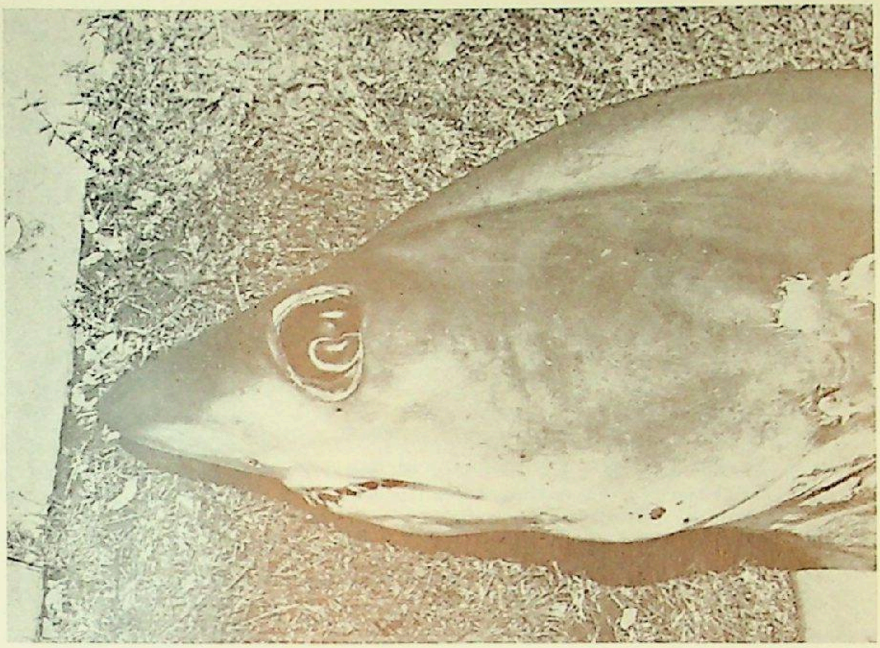

FIGURE 2. Head of San Clemente, California, bigeye thresher showing head groove which gives the shark a helmeted appearance. *Photograph by Jack W. Schott.*

SLENDER TUNA, *ALLOTHUNNUS FALLAI* SERVENTY, 1948

At 5 AM, November 15, 1963, the crew of the *New Sunbeam* set their bait net (lampara) successfully around a school of northern anchovies, *Engraulis mordax,* in Cerritos Channel, one of the innermost waterways of the Los Angeles-Long Beach harbor complex. While brailing their catch into live tanks aboard their boat (to be sold to sportfishermen as live bait), they noted a 30-inch fish that looked somewhat like a Pacific bonito, *Sarda chiliensis,* but it lacked the bonito's body stripes and large jaw teeth. One of the crew members, Richard McCann of Downey, was curious about the fish's identity, so he brought it to California State Fisheries Laboratory when his morning's bait-hauling activities were finished. Because of its extremely high gill-raker count (73 on the first arch on both sides), its identity was obvious, but nearly an hour elapsed before we could force ourselves to acknowledge that it was *Allothunnus fallai.* Previously, *Allothunnus* had never been captured north of lat. 35° S., had never been found in the new world, and was rare even where known.

The species was first captured off New Zealand in October 1911, and in 1916 and 1938 two additional individuals were taken in the same waters. These three specimens were preserved in the Canterbury Museum as *Sarda chiliensis* until 1948 when D. L. Serventy, recognizing them as generically and specifically distinct, described *Allothunnus fallai,* using the 1916 specimen as the type. Ten years later, in April 1958, a fourth was captured off Cape Peninsula, South Africa (Talbot, 1960). During 1960 and 1961, four slender tunas were taken off Tasmania (Olsen, 1962), and another off South Africa (Talbot, 1962), bringing the total to nine. The largest of these weighed "about 30 lb." according to the fisherman who caught it (Olsen, 1962), but the most reliable maximum weight seems to have been 18.5 lbs. while the longest fish was 96.5 cm, both from Tasmania. Our fish was 72.2 cm FL (77.6 cm TL) and it weighed 9.75 pounds (Figure 3, Table 3).

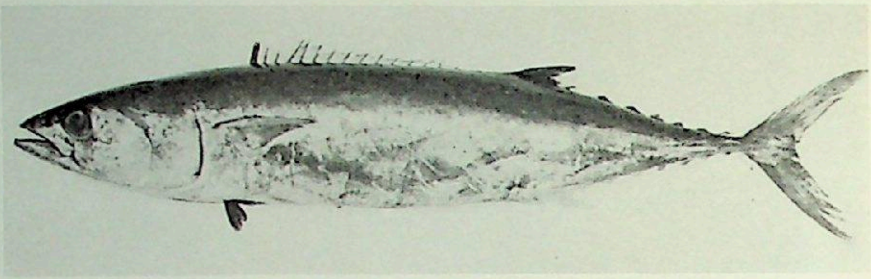

FIGURE 3. Slender tuna, 30 inches long (*FL*), 9¾ pounds, netted November 15, 1963, in Cerritos Channel, Los Angeles-Long Beach Harbor. *Photograph by Jack W. Schott.*

TABLE 3

Measurements and Selected Counts Made on a 9.75-Pound Male *Allothunnus fallai* from Long Beach, California

Measurements:	*Length (mm)*	*Proportion (thousandths of standard length)*
Standard length	694	–
Total length	776	1,118
Fork length	722	1,040
Head length	187	269
Snout length	55	79
Fleshy orbit diameter	29	42
Fleshy suborbital width	14	20
Maxillary length	65	94
Bony interorbital width	48	69
First gill raker below angle (length)	34	49
Snout to 1st dorsal insertion	218	314
Snout to 2nd dorsal insertion	452	651
Snout to anal insertion	473	682
Snout to pectoral insertion	197	284
Snout to pelvic insertion	204	294
Snout to anterior margin of anus	452	651
Snout to posterior edge of preopercle	143	206
Snout to anterior nostril	32.5	47
Snout to posterior nostril	48	69
Pectoral length	91	131
Pelvic length	53	76
Height 1st dorsal	broken	–
Height 2nd dorsal	58	84
Height anal	56	81
Pectoral to 1st dorsal insertion	81	117
Body depth at 1st dorsal insertion	131	189
Body depth at anus	126	182
Length of anus	18	26
Counts:		
Dorsal		XVII, 12+7
Anal		12+7
Pectoral		25
Gill rakers—left		27+46=73
—right		23+50=73
Vertebrae		39

The body of our fish was completely scaled dorsally, but below the midline of the side it was scaled only in the shoulder region, the scales extending ventrally to the pelvics which were encircled by a "tongue" of scales reaching 24 mm past their tips. Scales also covered the fish's ventral surfaces posterior to the first dorsal finlet. Thus our fish was scaleless on its ventral midsides and belly from about the pectoral tips to a point below the first dorsal finlet.

We did no dissecting other than making a slit in the belly to examine internal organs, and chipping through the skull beneath the gill cover to remove the left otolith (sagitta). (Dissections and other detailed studies will be made at the U. S. National Museum where the frozen fish is being sent.) We were able to note that our tuna was a male, that it lacked an air bladder, and that it had eaten 38 small anchovies. Olsen (1962) reported krill (euphausiids) in the stomach of one of the Australian specimens.

An X-ray revealed 39 vertebrae in our tuna.

The left otolith from our fish was compared with otoliths from other west coast scombrid genera in hopes it would furnish clues regarding the relationships of *Allothunnus* and its nearest allies (Figures 4, 5, 6, 7). As a result of our comparisons, we were able to distinguish the eastern Pacific scombrid genera by their otoliths (sagittae) alone, but we were unable to differentiate the various species if more than one occurred within any given genus.

Several authors have described and figured various scombrid sagittae (Frost, 1928, *Scomber scombrus, Thunnus thynnus*, and *Scomberomorus regalis;* Priol, 1946, *Thunnus alalunga;* Sanz-Echeverria, 1950, *Scomberomorus maculatus;* Bauzá-Rullán, 1958, *Auxis thazard* [=*rochei*]; 1959, *Germo* [=*Thunnus*] *alalunga*), but none had compared the otoliths of the various genera. Scombrid sagittae are quite distinct, and once their outline and general features are familiar, they are impossible to mistake (Figures 5-7). All resemble each other superficially (except *Scomber*), in that the rostrum is relatively long, thin, and brittle, the otolith margins are generally finely serrate, being almost lace-like in places; and the sulcus (groove on the inner face) is deep, slightly curved upward in its central portion, and has sharply-defined margins throughout.

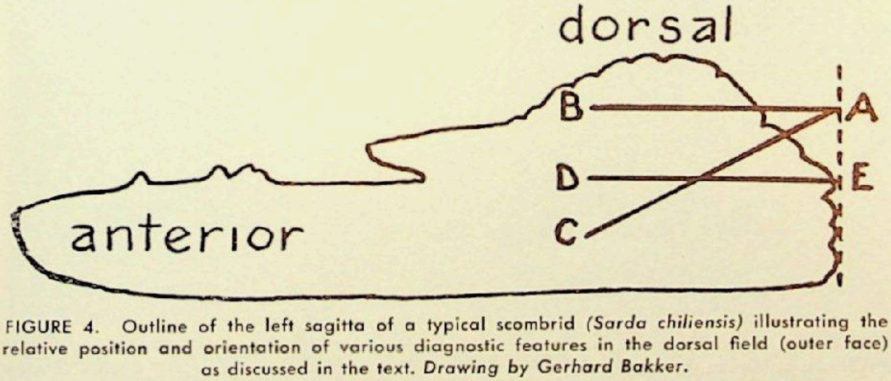

FIGURE 4. Outline of the left sagitta of a typical scombrid *(Sarda chiliensis)* illustrating the relative position and orientation of various diagnostic features in the dorsal field (outer face) as discussed in the text. *Drawing by Gerhard Bakker.*

The sagittae of *Allothunnus* (Figure 5a) are distinguishable from those of all other scombrid genera by their acute postero-ventral angle (the posterior and ventral margins converge at about a 45-degree angle). In all other genera, this angle varies between about 60 and 90 degrees. In addition, the outer face of the *Allothunnus* sagitta bears a slightly-raised, cone-shaped lump in the center of the dorsal field.

The sagittae of three species of *Sarda (chiliensis*, Figure 5b; *sarda*; and *orientalis*) were almost identical in physical features and outline. They could be distinguished from other scombrid sagittae by a raised, pyramid-shaped ridge in the dorsal field of the otolith's outer face (line D to E, Figure 4). The ridge terminates anteriorly at about the midpoint of the dorsal field.

The sagittae of *Scomberomorus* (*concolor*, Figure 5c; *sierra*; and *cavalla*) have a raised ridge near the postero-dorsal contour of the outer

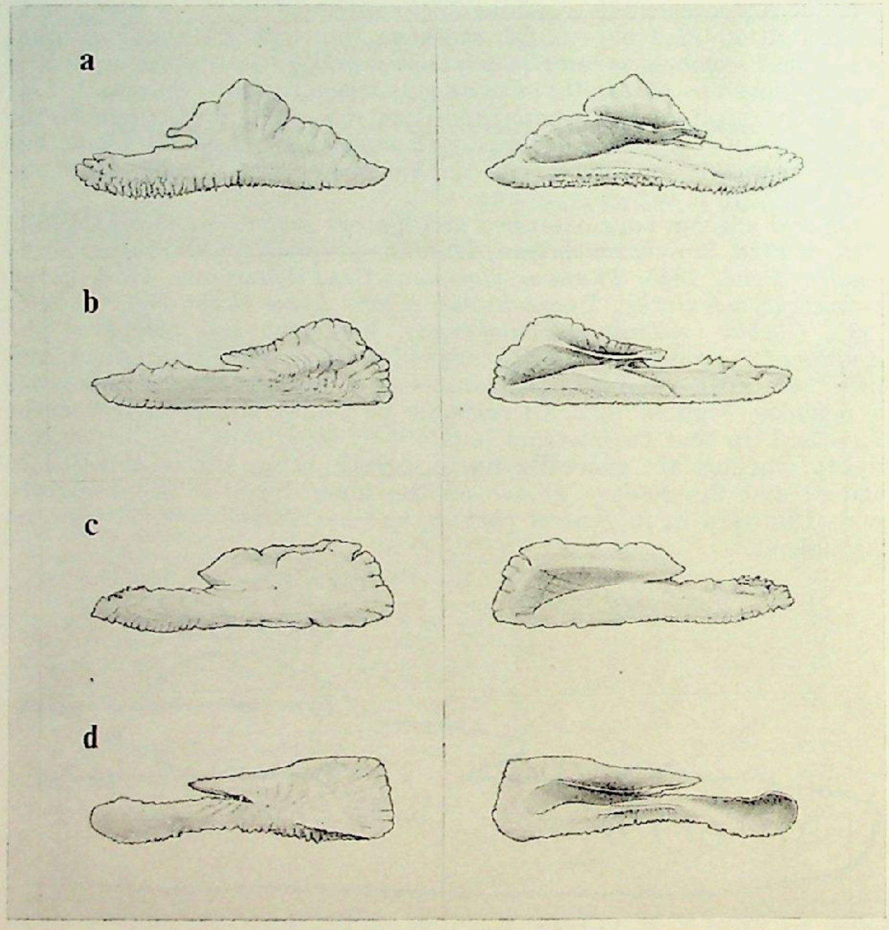

FIGURE 5. Outer (left) and inner (right) faces of left sagittae from (a) *Allothunnus fallai*; (b) *Sarda chiliensis*; (c) *Scomberomorus concolor*; (d) *Acanthocybium solanderi*. Otolith lengths in mm are: (a) 7.4; (b) 7.7; (c) 9.5; (d) 11.8. *Drawings by Gerhard Bakker.*

face. This ridge curves dorsally, is highest anteriorly, and terminates almost at the center of the dorsal field (line A to B, Figure 4).

Acanthocybium solanderi sagittae (Figure 5d) have no distinguishing lumps, bumps, or ridges on the outer face of the dorsal field, whereas all other scombrid genera do. Thus, while they can be identified by their "flatness" in the postero-dorsal field, the relatively long rostrum (exceeding 50 percent of total sagitta length) also distinguishes the wahoo otolith.

The sagittae of *Auxis rochei* (Figure 6a) and *A. thazard* have a raised ridge in the dorsal field (outer face) that runs diagonally downward from the postero-dorsal angle (line A to C, Figure 4). In *thazard*,

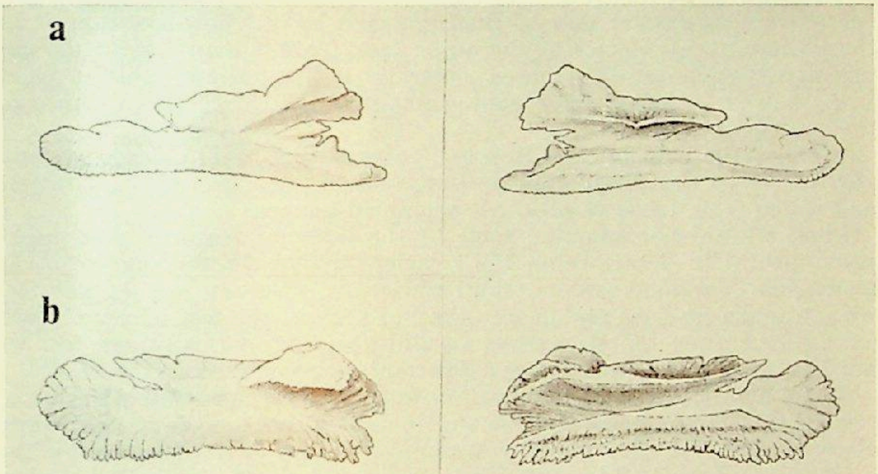

FIGURE 6. Outer (left) and inner (right) faces of left sagittae from: (a) *Auxis rochei;* (b) *Katsuwonus [= Euthynnus] pelamis;* (c) *Euthynnus lineatus;* (d) *Thunnus alalunga.* Otolith lengths in mm are: (a) 4.2; (b) 5.6; (c) 6.5; (d) 9.1. *Drawings by Gerhard Bakker.*

the ridge is more pronounced, and its rim curves dorsally along most of its length.

The otoliths of *Katsuwonus* [= *Euthynnus*] *pelamis* (Figure 6b), and *Euthynnus lineatus* (Figure 6c), *E. yaito*, and *E. alletteratus* were so closely similar they could not be readily distinguished from each other. The sagittae of all of these have a raised ridge (line D to E, Figure 4) in the postero-dorsal field (outer face) that curves dorsally along its entire length. The rim of the "platform" resulting from this dorsal flexure, aligns with the postero-dorsal margin of the otolith proper. The high (deep) rounded rostrum also sets *Euthynnus* sagittae apart from those of other scombrids.

The sagittae of *Thunnus* (*alalunga*, Figure 6d; *albacares*; *atlanticus*; *obesus*; and *thynnus*) can be distinguished by a "flow-like lump" in the postero-dorsal corner of the outer face. This "lump" gives the impression that the otolith folded ventrally at its postero-dorsal margin and "flowed" downward, reaching about one-third of the distance to the ventral margin.

Finally, the sagittae of *Scomber* (*diego*, Figure 7; *peruanus*; and *australasicus)* are distinct in outline, and in rostrum length, position, and shape from those of all other scombrid genera.

Since we did not examine some of the internal features that might prove useful in determining the relationship of *Allothunnus* to other scombrids (vascular system, skull structure, viscera), we do not feel we can make positive statements that will stand the test of time. However, based upon the structures we did examine critically, we feel we are in a good position to draw a few tentative conclusions.

In its habits it seems closer to *Sarda* than to other scombrid genera: several of the 10 specimens known, including ours, were caught quite close to shore in very shallow water—areas never frequented by the high-seas "tunas" (*Thunnus*, *Euthynnus*, *Auxis*, *Acanthocybium*) but which are attractive to *Sarda*. From the otoliths, *Allothunnus* appears to be more closely related to *Sarda*, than to any other scombrid genus. In body shape, it also aligns best with *Sarda*, but its 39 total vertebrae are fewer than found in *Sarda* (44 to 46), whereas all species of *Thunnus* and *Auxis* have 39 vertebrae as do some *Euthynnus*. In two respects, number of gillrakers and scalation, *Allothunnus* stands by itself among the scombrids.

Based upon this limited information, we feel that *Allothunnus* is most closely related to *Sarda*, but also closely allied to *Auxis* and *Euthynnus*, more so than to *Thunnus*. Confirmation of this must await detailed anatomical dissections, however.

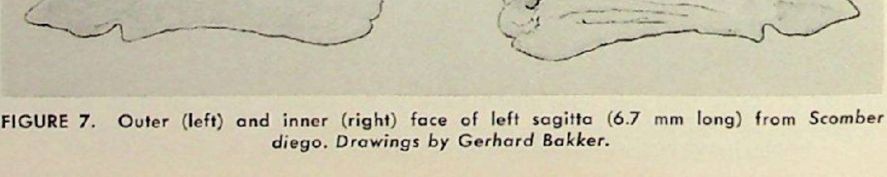

FIGURE 7. Outer (left) and inner (right) face of left sagitta (6.7 mm long) from *Scomber diego*. *Drawings by Gerhard Bakker.*

ACKNOWLEDGMENTS

Many individuals helped us in one way or another to complete our studies on these two species. We would particularly like to thank Gene Hachez, Costa Mesa, for saving the thresher, and Delaney Bros. Sea Food Co. Inc., Newport Beach, for calling it to our attention and placing it at our disposal. Benny Perez, City-Editor, *San Pedro News-Pilot*, gave us permission to use their photo of the San Clemente bigeye thresher. Carl L. Hubbs, Scripps Institution of Oceanography, furnished details on the Mission Bay bigeye thresher, and John G. Casey, U. S. Fish and Wildlife Service, Sandy Hook, New Jersey, Frank J. Mather III and Martin R. Bartlett, Woods Hole Oceanographic Institute, sent us details on recently-caught Atlantic specimens.

We also would like to thank John Williams, Long Beach, skipper of the *New Sunbeam*, and the several crew members, especially Richard McCann, Downey, who were responsible for saving the slender tuna. Frank H. Talbot, South African Museum, sent us details regarding the two South African slender tunas, and the UCLA Medical Center made X-rays of our fish for us.

Gerhard Bakker, Assistant Professor, Los Angeles City College, made all of the otolith drawings used to illustrate this paper, and Jack W. Schott, California State Fisheries Laboratory, took several of the photographs.

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CHROMATIC PATTERNS OF THE LEOPARD SHARK, *TRIAKIS SEMIFASCIATA* GIRARD[1]

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Photographic comparisons were made of the chromatic patterns of 47 leopard sharks of both sexes, 368 to 1334 mm TL, captured from Ventura County, California, to Angel de la Guardia Island, Gulf of California. A primary or basic chromatic pattern was observed in all fish. Fish longer than 737 mm TL showed additional secondary markings. About 100 undocumented observations of mostly large mature sharks confirmed the relationship of size to the primary and secondary patterns.

Primary marks are found on fish of all sizes in four regions on each side of the body. These have been termed saddle, mid-dorsal intersaddle, inferior intersaddle, and subsaddle marks. They are respectively designated by alphabetical coding A, B, C and D (Figure 1). The first number that follows the letter code is the serial position of that mark relative to the most anterior one. The second number (after the hyphen) indicates the frequency of occurrence in 47 observations.

OBSERVATIONS ON THE PRIMARY CHROMATIC PATTERN

Individual saddle, mid-dorsal intersaddle and inferior intersaddle marks varied in configuration and frequency on different specimens. Subsaddle marks were the fewest in both numbers and frequency of occurrence.

I. Saddle Marks (A)
  - A1) 13 solid, 34 broken or disconnected (Figure 2)
  - A4) 8 separated from C2, 39 connected to C2.
  - A6) not bridged over first dorsal but always extended onto fin.
  - A7) always bridged over mid-dorsal line of back, 37 extended onto 1st dorsal, 10 did not.
  - A10) always bridged over anterior portion of second dorsal.
  - A11) always bridged mid-dorsal line of back—some extended onto second dorsal.
  - A14) 37 bridged over back, 10 did not.
  - A15) 25 bridged over back, 21 did not.

II. Mid-dorsal Intersaddle Marks (B)
  - B6) 30 occurrences at base of first dorsal. Occasional marks above base of dorsal were not counted.
  - B10) 23 occurrences at base of second dorsal.

III. Inferior Intersaddle Marks (C)
  - C2) joined with A4 in 39 fish, separated in 8.

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[1] Submitted for publication February 1964.

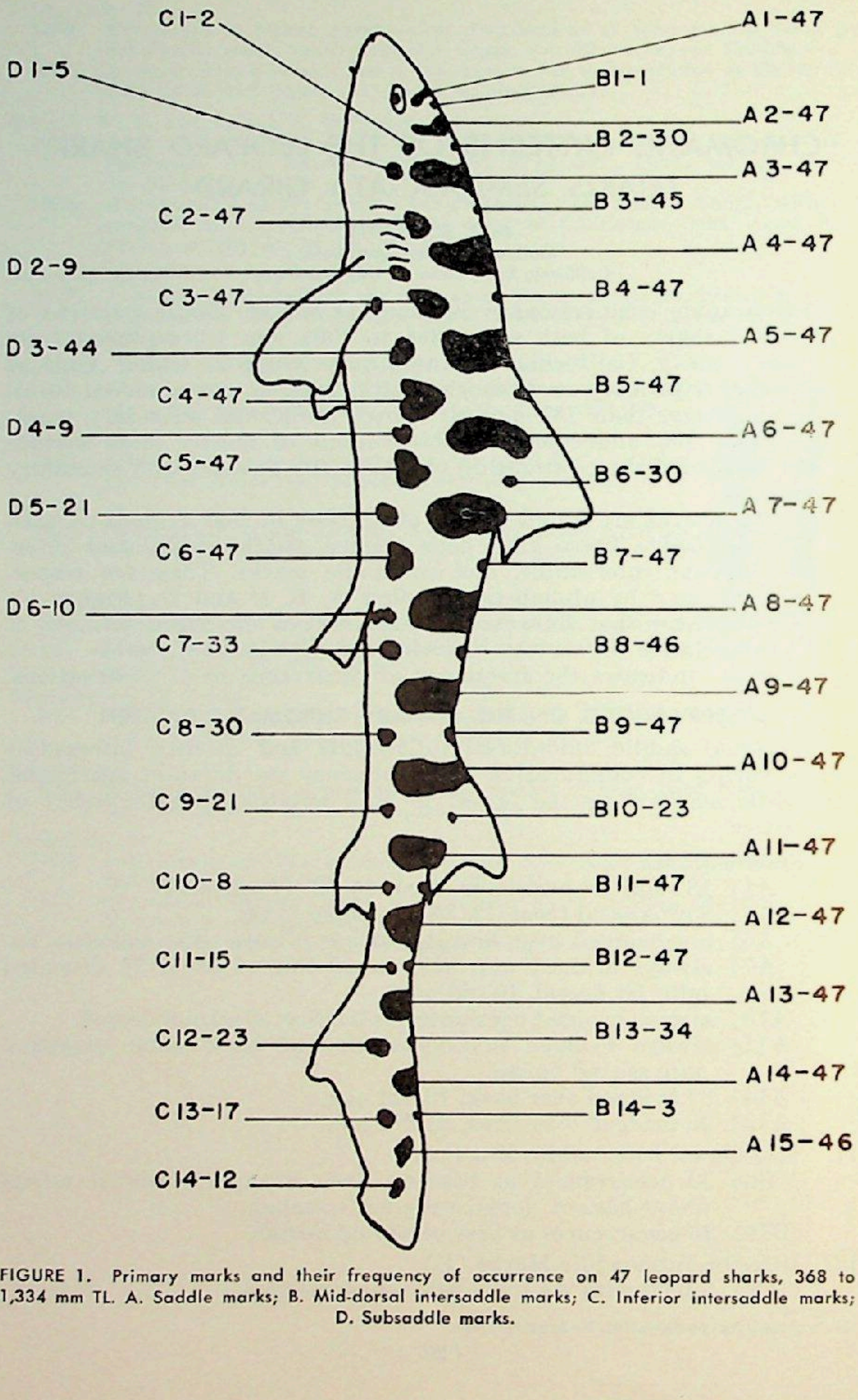

FIGURE 1. Primary marks and their frequency of occurrence on 47 leopard sharks, 368 to 1,334 mm TL. A. Saddle marks; B. Mid-dorsal intersaddle marks; C. Inferior intersaddle marks; D. Subsaddle marks.

Additional marks were seen on leopard sharks smaller than 737 mm but no regular pattern of placement was observed. Single or sometimes paired spots occasionally were found anteriorly between the mid-dorsal intersaddle and the inferior intersaddle marks.

SECONDARY CHROMATIC MARKS

Secondary chromatic marks are found on fish longer than 737 mm TL, scattered between the marks of the primary pattern (Figure 3). They were most numerous on the back between the saddle marks, relatively fewer on the dorsal and caudal fins, and least numerous on the belly and pectorals.

The secondary marks first appear on fish as small as 737 mm though very faint pigmentation was observed on some fish approaching this size. They occur on both sexes throughout the geographical distribution of the species, suggesting that their appearance may be related to first sexual maturity.

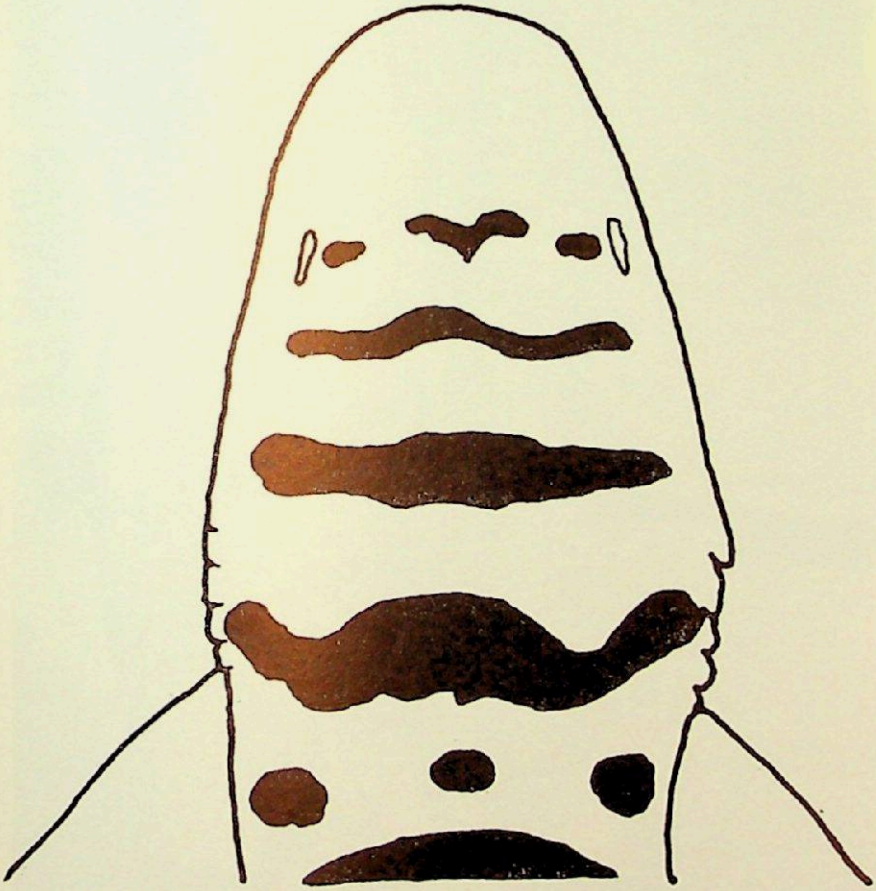

FIGURE 2. Broken or interrupted first saddle mark. Tracing of photograph.

The degree of contrast between the marks and their background varied, ranging from a grayish-brown background with only slightly darker markings to near-black markings on a metallic silver background. Larger marks were sometimes outlined by a darker border (Figure 3) and occasionally primary marks were fused together (Figure 4).

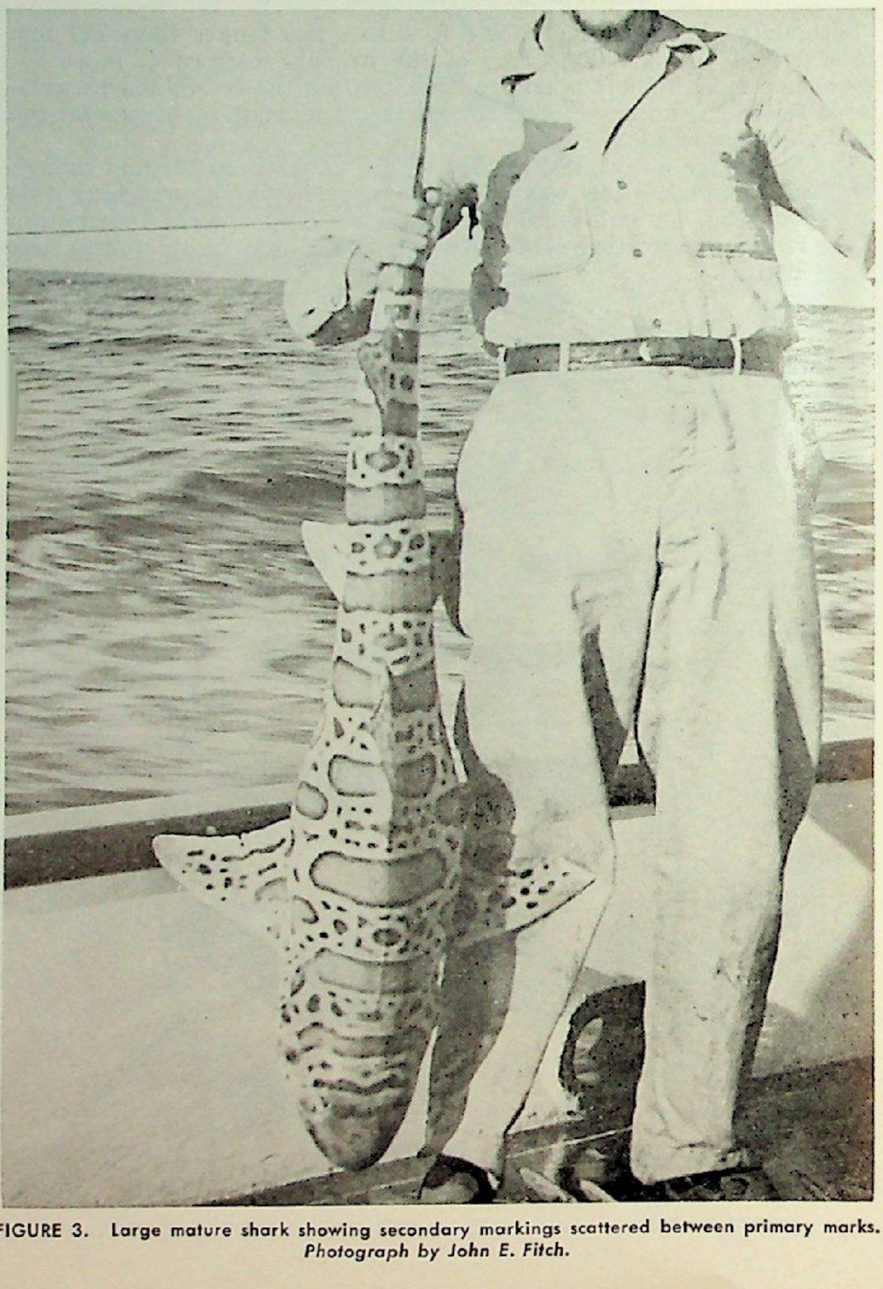

FIGURE 3. Large mature shark showing secondary markings scattered between primary marks. *Photograph by John E. Fitch.*

The relative contrast between the marks and their background may be related to the color of the shark's habitat. Parker and Porter (1934) demonstrated that the color phase of the spiny dogfish (*Squalus acanthias*) could be reversed by placing a light colored shark in a black tank or a dark shark in a light tank.

ANOMALOUS CHROMATIC PATTERNS

One of the two 11-inch leopard sharks (Figure 5) captured in a beach seine at Goleta, California, in 1953 and a specimen (Figure 6) captured in 1946 in San Quintin Bay, Baja California, exhibited anomalous chromatic markings. The markings were much smaller, more numerous and irregular in shape. Morphometric methods advanced by Rosenblatt and Baldwin (1958) were followed in describing the one normal and two anomalous specimens (Table 1). A third chromatic anomaly was observed by David Brown, Curator of Mammals, Marineland of the

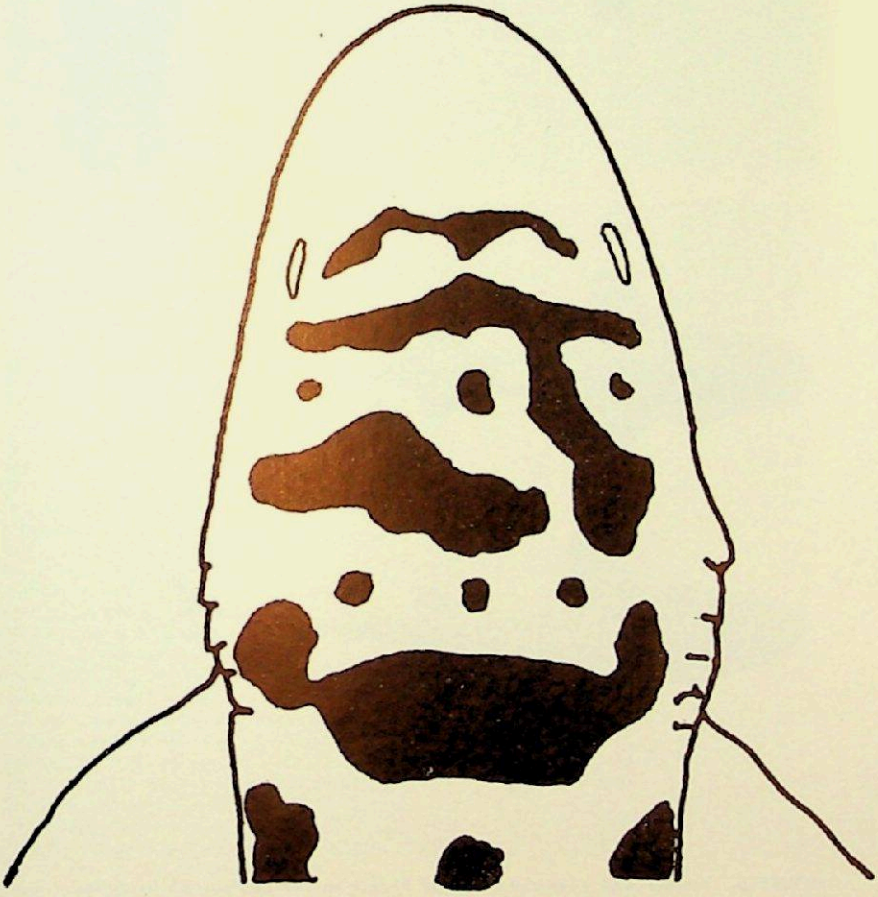

FIGURE 4. Saddle mark number three is interrupted and fused to number two. Tracing of photograph.

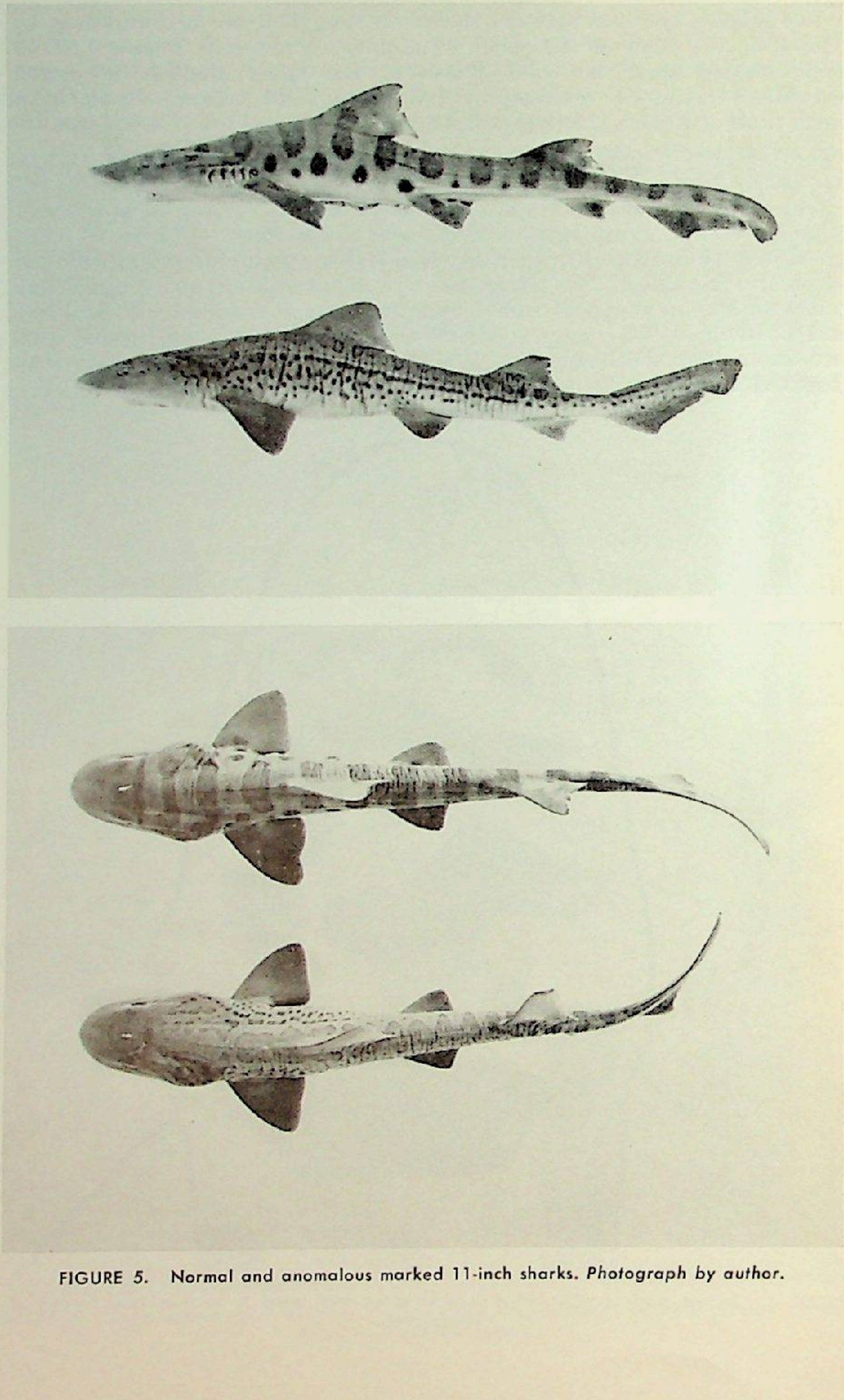

FIGURE 5. Normal and anomalous marked 11-inch sharks. *Photograph by author.*

Pacific (pers. comm.), but detailed information was not available for comparison.

TABLE 1

Morphometrics of a Normal and Two Chromatic Anomalous Leopard Sharks, *Triakis semifasciata* (Total length in millimeters, all others in thousands of TL)

	Goleta Beach Normal	*Goleta Beach Anomaly*	*San Quintin Bay Anomaly*
	Male	*Female*	*Female*
Total length	282	268	684
Fork length	851	866	860
Tip of snout to upper caudal origin	777	795	776
Tip of snout to origin D1	312	334	292
Tip of snout to origin D2	582	597	586
Tip of snout to anal origin	638	649	648
Tip of snout to pelvic origin	436	463	418
Tip of snout to pectoral origin	220	235	205
Trunk width over pectoral origin	99	105	110
Trunk height at pectoral origin	92	99	101
Head length (to 5th gill slit)	223	228	202
Head width at angles of mouth	119	127	99
Head width at outer end of nostrils	90	97	72
Interorbital width	89	90	75
Fleshy orbit diameter	28	28	21
Mouth width	67	71	57
Mouth length	27	26	23
Length of labial fold	46	54	44
Preoral length	67	67	51
Prenarial length	39	41	31
Nostril length	25	26	19
Internarial distance	39	39	31
Length of first gill slit	28	26	21
Length of second gill slit	30	24	21
Length of third gill slit	25	24	21
Length of fourth gill slit	19	22	19
Length of fifth gill slit	16	19	15
Origin of pectoral to first gill slit	36	37	34
First dorsal height	85	82	83
First dorsal, length of base	110	106	135
First dorsal, height of posterior margin	85	90	99
First dorsal, length of free rear tip	36	37	38
Second dorsal height	75	63	69
Second dorsal, length of base	90	93	105
Second dorsal, length of free rear tip	41	34	29
Anal height	40	42	41
Anal, length of base	59	63	66
Anal, length of free rear tip	32	30	25
Pelvic length	87	86	92
Pelvic, width of base	57	56	63
Pelvic origin to anal origin	202	187	222
Pelvic origin to pectoral origin	238	254	238
Pectoral, length of anterior margin	135	136	148
Pectoral, length of posterior margin	67	67	61
Pectoral, length of distal margin	96	101	121
Caudal, length of upper lobe	218	205	224
Caudal, length of lower lobe	96	82	97
Origin of first dorsal to origin of second	287	280	304
Origin of second dorsal to origin of caudal	192	190	177
Origin of anal to lower caudal origin	124	134	63
Tip of tail to subterminal notch	78	78	83
Length of claspers	26	--	--

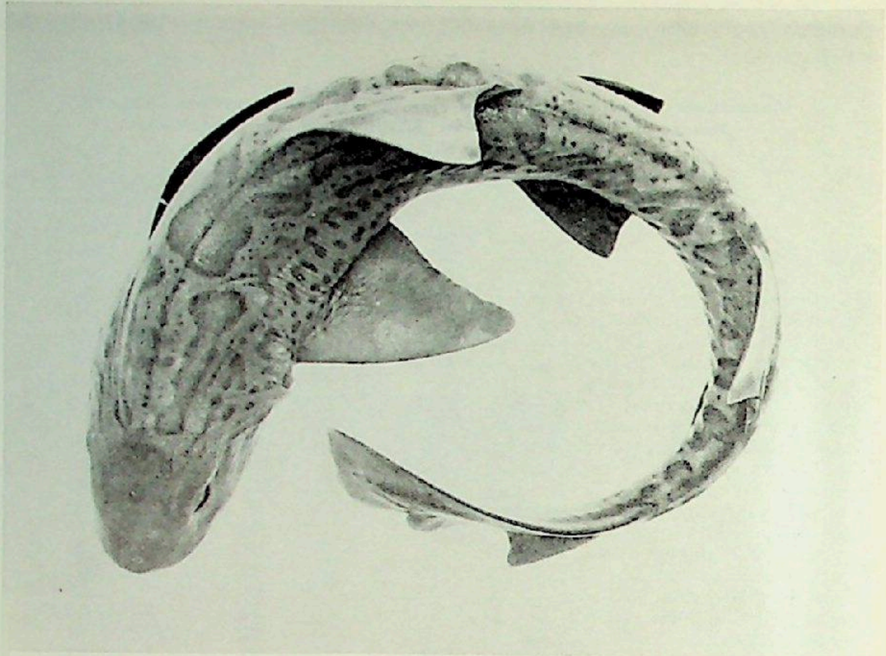

FIGURE 6. Anomalous marked leopard shark from San Quentin Bay, Baja California. *Photograph by author.*

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NOTES

CALIFORNIA STRIPED BASS ESTIMATES FOR 1961 [1]

Periodic surveys of California's licensed anglers have been used to provide information on trends in sport fish catches, angling pressures, and changes in major gamefish populations, including striped bass, *Roccus saxatilis* (Walbaum), since 1935. The results of these surveys have been summarized by Ryan (1959) and Seeley, *et al.*, (1963). This note reports striped bass estimates based on a postcard survey of the 1961 licensed anglers.

Postcard catch estimates have been shown to be exaggerated (Wendler, 1960; Bjornn, 1961), and have been used primarily for indicating trends. However, this use is also questionable. Postcard estimates of California's ocean sport-salmon catch have been 2.8 to 5.3 times larger than more accurate catch estimates based on partyboat logs and creel censuses, and the trends indicated by these two methods do not agree (Jensen, 1964). The exaggeration and reliability of the striped bass estimates presented here (Table 1) are not known.

TABLE 1

Striped Bass Estimates for Successful Anglers in 1961

Sport fishing licenses sold	1,490,847
Questionnaires mailed	10,364
Questionnaires returned	3,371
Usable returns	3,351
Projection factor *	444.9
Returns reporting striped bass	442
Successful anglers	197,000
Standard error	8,700
Percentage of all licensees	13.2
Mean annual catch	13
Standard error	1.3
Median annual catch	5
Total annual catch	2,547,000
Standard error	280,000
Mean annual days	16
Standard error	1.3
Median annual days	8
Total annual days	3,184,000
Standard error	294,000
Mean catch per angler day	0.8

* Total sport fishing license sales divided by usable returned questionnaires.

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[1] Submitted for publication November 1963. This work was performed as part of Dingell-Johnson Project California F-9-R, "A Study of Sturgeon and Striped Bass," supported by Federal Aid to Fish Restoration funds.

Methods employed in this survey were identical to those used by Seeley, *et al.*, (1963). Only data from successful anglers were used, since information from unsuccessful anglers could not be evaluated accurately from the questionnaire.

Postcard questionnaires were mailed to 10,364 licensed anglers. About 32 percent (3,351) of these returned usable cards, giving a sample of 0.22 percent of all licensed anglers. Striped bass were reported on 442 returns.

The total catch, the mean catch per day, and the number of successful anglers declined from the 1960 estimates. However, the total catch has been exceeded only by the 1960 catch. Total effort by successful anglers continued to increase.

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Arnold B. Albrecht, Inland Fisheries Branch, California Department of Fish and Game, Sacramento.

WEIGHT-LENGTH RELATIONSHIP FOR BLUEFIN TUNA IN THE CALIFORNIA FISHERY, 1963

Weights and lengths were taken from 367 bluefin tuna (*Thunnus thynnus*) caught in the California fishery and landed at Terminal Island during the summer of 1963. The fish were measured to the nearest millimeter and one-tenth pound and ranged in fork length from 558 to 1,784 mm and in weight from 9.0 to 265 pounds.

The solution of equation $W = 0.20334 \times 10^{-6} L^{2.79012}$, ($\text{Log } W = -6.69177 + 2.79012 \text{ Log } L$) is in Table 1. The upper confidence limit of the exponent of L is 2.81788 and the lower 2.76236 at the 95 percent level.

This equation may be compared with the one derived from 1962 data: $W = 0.98404 \times 10^{-7} L^{2.89727}$ ($\text{Log } W = -7.00699 + 2.89727 \text{ Log } L$) (Bell, N.D.).

The bluefin tuna weight-length equation and table were programmed by Norman J. Abramson, processed by David J. Mackett and run on an IBM 7094 at Western Data Processing Center.

TABLE 1

Calculated Weights by Length for Bluefin Tuna, 1963

Length (cm)	*Weight (lbs)*	*Length (cm)*	*Weight (lbs)*	*Length (cm)*	*Weight (lbs)*
50.0	6.90	90.0	35.56	130.0	99.20
51.0	7.29	91.0	36.67	131.0	101.34
52.0	7.70	92.0	37.81	132.0	103.52
53.0	8.12	93.0	38.96	133.0	105.72
54.0	8.55	94.0	40.14	134.0	107.95
55.0	9.00	95.0	41.35	135.0	110.22
56.0	9.46	96.0	42.57	136.0	112.51
57.0	9.94	97.0	43.82	137.0	114.83
58.0	10.44	98.0	45.09	138.0	117.19
59.0	10.95	99.0	46.39	139.0	119.57
60.0	11.47	100.0	47.71	140.0	121.99
61.0	12.01	101.0	49.05	141.0	124.43
62.0	12.57	102.0	50.42	142.0	126.91
63.0	13.14	103.0	51.81	143.0	129.42
64.0	13.73	104.0	53.23	144.0	131.96
65.0	14.34	105.0	54.67	145.0	134.54
66.0	14.97	106.0	56.13	146.0	137.14
67.0	15.61	107.0	57.62	147.0	139.78
68.0	16.27	108.0	59.14	148.0	142.45
69.0	16.94	109.0	60.68	149.0	145.15
70.0	17.64	110.0	62.24	150.0	147.88
71.0	18.35	111.0	63.83	151.0	150.65
72.0	19.08	112.0	65.45	152.0	153.45
73.0	19.83	113.0	67.10	153.0	156.28
74.0	20.59	114.0	68.77	154.0	159.15
75.0	21.38	115.0	70.46	155.0	162.05
76.0	22.18	116.0	72.18	156.0	164.98
77.0	23.01	117.0	73.93	157.0	167.95
78.0	23.85	118.0	75.71	158.0	170.95
79.0	24.72	119.0	77.51	159.0	173.99
80.0	25.60	120.0	79.35	160.0	177.06
81.0	26.50	121.0	81.20	161.0	180.16
82.0	27.42	122.0	83.09	162.0	183.30
83.0	28.37	123.0	85.01	163.0	186.48
84.0	29.33	124.0	86.95	164.0	189.69
85.0	30.32	125.0	88.92	165.0	192.93
86.0	31.32	126.0	90.92	166.0	196.21
87.0	32.35	127.0	92.94	167.0	199.53
88.0	33.40	128.0	95.00	168.0	202.88
89.0	34.47	129.0	97.09	169.0	206.27

TABLE 1—Continued

Calculated Weights by Length for Bluefin Tuna, 1963

Length (cm)	*Weight (lbs)*	*Length (cm)*	*Weight (lbs)*	*Length (cm)*	*Weight (lbs)*
170.0	209.69	195.0	307.49	220.0	430.53
171.0	213.15	196.0	311.91	221.0	436.01
172.0	216.65	197.0	316.37	222.0	441.54
173.0	220.18	198.0	320.87	223.0	447.11
174.0	223.75	199.0	325.41	224.0	452.73
175.0	227.36	200.0	330.00	225.0	458.39
176.0	231.00	201.0	334.62	226.0	464.09
177.0	234.68	202.0	339.29	227.0	469.85
178.0	238.40	203.0	343.99	228.0	475.64
179.0	242.15	204.0	348.74	229.0	481.49
180.0	245.95	205.0	353.53	230.0	487.38
181.0	249.78	206.0	358.37	231.0	493.31
182.0	253.65	207.0	363.24	232.0	499.29
183.0	257.56	208.0	368.16	233.0	505.32
184.0	261.50	209.0	373.12	234.0	511.40
185.0	265.49	210.0	378.12	235.0	517.52
186.0	269.51	211.0	383.17	236.0	523.69
187.0	273.57	212.0	388.25	237.0	529.90
188.0	277.67	213.0	393.39	238.0	536.16
189.0	281.81	214.0	398.56	239.0	542.47
190.0	285.99	215.0	403.78	240.0	548.83
191.0	290.21	216.0	409.04	241.0	555.23
192.0	294.47	217.0	414.35	242.0	561.68
193.0	298.77	218.0	419.70	243.0	568.18
194.0	303.11	219.0	425.09	244.0	574.73

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1916, THE PIONEER YEAR OF TUNA TAGGING ON THE PACIFIC COAST OF NORTH AMERICA

The first tagging of tunas in the eastern Pacific Ocean was performed in 1916 by Edward C. Johnston of the United States Bureau of Fisheries, as evidenced in a manuscript by Johnston entitled, ''Long-Finned Tuna, Albatross 1916'', a copy of which is in the library of the Inter-American Tropical Tuna Commission. In this, Johnston describes work carried out by the steamer *Albatross,* and gasoline launch *Bijo* from April 1916 to April 1917, off California and Baja California, Mexico. We have been unable to find any published reference to Johnston's manuscript. It seems that the first tagging of tunas off the Pacific coast of North America has slipped past the scrutiny of others who have reviewed the work of prior investigators in this field (Rounsefell and Kask, 1945; Alverson and Chenoweth, 1951; Wilson, 1953; and Marr, 1962).

Because Johnston's work took place during the formative years of southern California's tuna industry, we searched the trade journal, *Pacific Fisherman,* and found four references to his work (*Pacific Fisherman* 1916a; 1916b; 1916c; 1917).

One objective of the Bureau's 1916 work at sea was to determine the direction, duration and probable causes of the migrations of long-finned tuna, or albacore (*Thunnus alalunga*). Consequently the *Albatross* spent most of her time at or beyond the outer edge of the most productive albacore fishing area, and few large catches were made. Only fish taken in unusual locations were tagged. The tags used were silver, circular shaped, bore the initials B.F. and a number, and were riveted to the fish's opercle or sub-opercle.

Insofar as we can determine from Johnston's manuscript, the information concerning the first tagged tuna releases off the Pacific coast of North America may be summarized as follows:

Date	*Number and species tagged*	*Location of release*
1) Exact day unstated but evidently near the end of April and before May 1, 1916.	Five, yellowfinned (sic) tuna A total of 12 fish were captured. (Yellowfin tuna, *Thunnus albacares.*)	Location not precisely stated, but believed to be in the immediate vicinity of Cape San Lucas, Baja California.
2) June 6, 1916	Three, Long-finned tuna (Albacore)	About 20 miles north of the San Benito Islands
3) Sept. 5, 1916	Nineteen, long-finned tuna (small albacore, ave. wt. 7.9 lbs.)	Southwest of San Martin Island.

The only reported recovery was one of three albacore tagged on June 6, 1916. It weighed 12 pounds and was 26 inches long when tagged. The fisherman who reported the recovery found the button tag loose on the deck of his vessel in August 1916, after beheading and cleaning his catch at sea near San Miguel Island, about 400 miles north of the tag release area near the San Benito Islands.

This pioneer tagging experiment, although limited in extent, initiated tuna tagging experiments in the eastern Pacific Ocean. Within recent years tuna tagging has progressed in development and magnitude and continues to provide invaluable information concerning migrations, and other data on this important marine resource.

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BOOK REVIEWS

Fish as Food. Volume 2: Nutrition, Sanitation, Utilization

Edited by Georg Borgstrom, Academic Press, New York, 1962; xviii + 777 pp., illustrated; $25.

This is the second volume of this series of review articles on utilizing fish as food. The high standard of quality set in Volume 1 has been maintained in this unit.

The series is intended for use primarily by fishery technologists and processors. These volumes will be extremely valuable as reference works for technologists in their quest for new and better fishery products. The authors are from several foreign countries and give world-wide coverage to these dissertations on the use of fishery products. Extensive bibilographies following each chapter provide broader coverage.

Considerable space is devoted to the nutritional aspects of the various fishes and fishery products. An analysis of the use of fishery products showed that protein-deficient nations of Africa and South America produce large quantities of fish meal which are primarily used by well-fed nations of North America and Western Europe for feeding livestock.

To balance the discussion of nutritional benefits derived from increased use of fish, a few chapters are included on potential dangers. The chapter on fish poisoning is timely in view of recent occurrences of botulism in fishery products. Excellent coverage is given to the possible contamination of fishes by polluting the environment with domestic and industrial waste and radioactive materials.

A final long chapter on recent trends in utilizing fish and shellfish will provide considerable "food for thought" for the American fishing industry and all those concerned with it.—*E. A. Best, California Department of Fish and Game.*

The Last Horizon

By Raymond F. Dasmann, The Macmillan Company, New York, 1963; vii + 279 p., illustrated; $6.95.

A book that philosophically approaches mankind's future on earth, *The Last Horizon* carries a dual message. First, it discusses the necessity for setting aside some wild, unmodified lands as sanctuaries where man can visit and leave his problems behind. Second, it shows the absolute necessity for man to limit his numbers if these sanctuaries are to be possible and if he is to use them.

There are 12 chapters in *The Last Horizon*. In the introduction and nine other chapters Dr. Dasmann discusses how mankind has affected ecological succession in such wild portions of the earth as the deserts, forests, jungles, and grasslands. The final two chapters are devoted to controlling human populations. References, by chapter, are given at the end of the book. Line drawings and graphs illustrate the text throughout while a separate section contains 46 photographs of various world scenes.

This is a most interesting story about the earth's far-flung continents, as seen through a scientist's eyes, that climaxes in his message regarding the future of mankind.—*William L. Craig, California Department of Fish and Game.*

Fish and Fishing

By Maynard Reece, Meredith Press; Des Moines, Iowa, 1963; 224 p., profusely illustrated in black and white and color; $7.95.

Author Reece's fine art combined with technical assistance (apparently in large part by Dr. Reeve M. Bailey) has resulted in an informative and colorful practical fishing guide for the family.

The contents are divided into eight chapters: chapter one, "Where To Go Fishing" is a rather misleading title—more appropriately "How To Go Fishing." Seven trips designed for the family are described starting with the "Auto Trip" and concluding with a high country "Pack Trip."

Chapter two, "How To Catch Fish," includes much more informative material such as methods, bait, lures, and equipment. The fundamentals of still fishing, trolling, bait casting, fly casting, and spin fishing are briefly covered, concluding with the proper technique of releasing unwanted fish.

Chapter three, "Where To Catch Fish," describes, mainly by color illustrations, where the six most popular families of fishes are likely to be found and caught.

Chapter four is entitled "When To Fish." Besides the obvious answer the author gives, and the course most avid anglers follow "any time the opportunity arises," he considers factors that will increase the angler's success: weather conditions, time of day, and the time of year in relation to fishing. Chapter five, "How To Identify Fish," is handled largely with drawings showing external identification characteristics. A very brief discussion of some of these morphological characteristics is given. Color illustrations are used to demonstrate color variations due to environment and age.

Chapter six, "Fresh Water Fishes of North America," is the largest and most informative portion of the book. A resumé of the most important game fish families is presented with color illustrations and a brief description of 80 species, including techniques used to capture them.

Chapters seven and eight deal with "How To Clean Fish," and "How To Cook Fish." Methods on how to clean panfish and the art of filleting larger fish are provided. Finally the reader is informed of how to cook his catch while in the field and at home, including two methods of smoking fish.

I feel the author has accomplished his goal of providing basic information for family fishing fun. The splendid paintings by Maynard Reece alone are worth more than the price of this colorful volume.—*James A. St. Amant, California Department of Fish and Game.*

Echinoderms

By David Nichols, Hillary House Publishers Ltd., New York, 1962; 200 pp., 26 figs.; $3.

This informative little monograph typifies the excellent work done by British zoologists. The purpose of the book is, in the author's words, "to present an introductory survey of the basic structure, adaptive radiation and evolutionary history, as far as it is known, of the living and fossil groups; to treat at greater length some problems which have a general biological interest; and to view the phylum in perspective among the rest of the animal kingdom." Dr. Nichols further states that he gives only brief treatment to those subjects so comprehensively covered by Dr. L. H. Hyman, and concentrated his book on other topics.

The book is weighted toward an understanding of echinodern fossil history and phylogeny. Dr. Nichols devotes a full chapter to each of the five existing classes of echinoderms. Other chapters cover such subjects as: pentamerous symmetry and the echinoderm skeleton; spines and pedicellariae; the tube feet and their evolution; larval forms and their metamorphosis; extinct forms; the phylogeny of the echinodermata; and the relationships of the echinodermata to other phyla. An appendix follows these chapters which gives a classification of the echinoderms, both living and fossil. An excellent bibliography accompanies the text.

A factor which aids in lifting this volume above the ordinary is the excellence of the line drawings accompanying the text. Most of the figures depict the complex anatomy of the diverse forms clearly and in fine detail. The book is well written and will be an invaluable aid to students and professionals.—*Michael L. Johnson, California Department of Fish and Game.*

Politics and Conservation

By Richard A. Cooley, Harper & Row, Publ., Inc., New York, 1963; 231 p., illustrated; $5.

This is a study of the underlying causes for the decline of a great fishery where the implementation of public policy failed to sustain the resource at a high level. The author describes the Alaska salmon fishery from the aboriginal era to the present, together with the forces which influenced the formulation and execution of federal conservation policies. Mr. Cooley considers all factors and concludes that the level of production and hence, the pattern and extent of exploitation, has been the result of the action and interaction of many different forces and pressures—biological, economical, political, and social. In the introduction Senator Ernest Gruening, with simpler language, ascribes the state of the fishery to greed, ignorance, politics, and federal mismanagement.

The subject is controversial. The critical will find errors. Nevertheless, this is a penetrating study concerning a resource which has many parallels in fisheries throughout the world. It is a well-documented, fascinating, and enlightening book. Anyone will profit by reading it.—*Tom Jow, California Department of Fish and Game.*

Snake Lore

By John Crompton, Doubleday & Co., Inc., New York, 1964; 152 p., illustrated; $3.95.

This is a book of popular appeal, filled with a host of lively anecdotes. Unfortunately the author did not have a professional herpetologist check his manuscript, as this might have eliminated a number of inaccuracies. He states that the rear-fanged snakes are poisonous only to small creatures; yet a well-known herpetologist was killed recently by the bite of a boomslang. He says that boas belong to South America, with the exception of two in India; yet boas extend northward through Central America and Mexico, with two small species in California. He says rattlesnakes do not get a new rattle segment at every moult, therefore the age cannot be told from the rattle; the latter statement is correct, since the number of moults per year is variable, but not the former. He says snakes never swallow anything decomposed: rattlesnakes, among others, frequently eat animals that are very ripe. He says if a snake is non-poisonous, its prey will probably reach the gullet alive, which is, of course, not the case with the constrictors. And so on.

Other statements are open to question: for instance, that pet snakes become fond of their owners and are uneasy in their absence, or that they prefer women to men. And there is little excuse for the confused statement that, "The huge python is a favorite prey [of driver ants], if drivers can be said to have a favorite prey, for they just eat every creature they come across."

However, despite such statements, the book is, as I have said, very entertaining to read. The author spent some time with the South Africa Mounted Police, so has much to contribute about the snakes of Africa, as well as those of his native England. And the layman will find considerable information about structure and habits of these animals in general.—*Anita E. Daugherty, California Department of Fish and Game.*

Myth and Maneater, The Story of the Shark

By David Kenyon Webster, W. W. Norton & Co., New York, 1963; 223 pp., illustrated; $4.95.

This is one of many books that has appeared within the last two years purporting to explain all the known facts about sharks. The book is written in a narrative style that will appeal to the laymen for whom it is intended. It discusses, in general terms: shark biology, taxonomy, feeding habits, and attack behavior.

Much of the book is devoted to examples and discussions of known shark attacks. The only conclusion that can be drawn from these examples is the old cliché: "The only thing predictable about shark behavior is that in any given situation, they are completely unpredictable."

The best known, most important, and widespread maneaters are discussed in separate chapters. The hammerhead, great blue, great white, tiger, and mako sharks are discussed. The author says the title of "maneater" should be given to the tiger shark, rather than the great white shark. While the great white shark is responsible for many unprovoked attacks on the coasts of the United States, the tiger shark is the undisputed king of the maneaters on a world-wide basis.

This volume will make an interesting addition to the library of skindivers, fishermen, ocean swimmers, boaters, and others interested in sharks.—*Michael L. Johnson, California Department of Fish and Game.*

Sharks and Survival

Edited by Perry W. Gilbert, D. C. Heath and Co., Boston, 1963; xiv + 578 p., illustrated; $9.90

An Australian bather in waist deep water, 10 to 50 yards offshore, has a very slight chance of being attacked by a shark, especially if it is between 2 and 6 p.m. His chances of such an attack are slightly better if the water is murky, if he is alone or in a small group, if the water is warmer than 70° F., and if he is wearing a bright, contrasting bathing suit. The fact that he may be immersed in a "guaranteed shark repellent" does not improve his lot one way or the other. However, if he is attacked, perhaps he can find solace in the knowledge that he has better than a 50 percent chance to survive. These and hundreds of other interesting statistics can be gleaned from the pages in *Sharks and Survival.*

Twenty of the world's foremost authorities have teamed up and prepared one of the most comprehensive, but least emotional, accounts on the shark menace that has yet come off the press.

The first meaty chapter contains some all new "keys" for identifying shark genera. This is followed by some excellent descriptive material, including helpful photographs and drawings.

Two major sections contain chapters on shark behavior and sense organs, while succeeding pages deal with dangerous sharks, patterns of shark attack, and meeting the shark-hazard problem. An appendix lists individually nearly 1,200 documented attack cases, some occurring over 100 years ago. For each attack, where data were available, the listing includes date, victim's name, attack locality, number of persons involved, and whether or not the attack was fatal.

Many parts of the book read like a novel, holding one's avid attention for lengthy periods. Others make equally interesting reading, but contain so many miscellaneous facts they are best used for reference purposes. Thus *Sharks and Survival* should be equally at home in the "reading" section of the bookshelf, or among the "reference" items. Only the central nervous system chapter did not have my full approval, mostly because I could not see the logic behind having such lengthy comparisons with, and discussions of, teleost "brains" in a book on sharks.—*John E. Fitch, California Department of Fish and Game.*

Fishes of the Western North Atlantic, Part 3, Soft-rayed Bony Fishes

Edited by Yngve H. Olsen, Sears Foundation for Marine Research, Yale Univ., New Haven, Conn., 1963; xxi + 630 p., illustrated; $27.50

At long last, 10 years after Part 2 was published, Part 3 is available. I suspect much of the lengthy interim resulted from procrastinating authors rather than a shortage of knowledge about the various fish families treated. Eleven authors collaborated in producing this tome.

The completeness and quality of coverage in the first two volumes spoiled me somewhat, and left me a bit disappointed with this one. Particularly evident was a shortage of up-to-date literature citations. The most recent listings I could find in the various sections were: gars and sturgeons, 1955; *Elops*, 1943; *Tarpon*, 1944; *Megalops*, 1949; *Albula*, 1961; *Dixonina*, 1942; engraulids, 1943 except for a 1949 paper by Schultz; clupeids, 1953 except for a 1957 "herring" reference and some to 1960 for *Dorosoma;* salmons, 1961; and osmerids, 1957. Thus, several recent revisionary works have been omitted (*i.e.*, osmerids and *Etrumeus*).

On the brighter side, some bonus items included in Part 3 are especially useful. There is an enlightening discussion of higher fish categories (superclass, class, subclasses, and orders), and an illustrated section on the names of bones of the skull and pectoral girdle. "Keys" are scattered throughout the volume, with those to suborders and families of soft-rayed bony fishes confined to a single section. The family keys would be difficult to improve upon (I tried them out with some complicated items), but the key to the suborders of Isospondyli left me cold. (It is the type that requires taking an unfamiliar specimen so completely apart to view head bones, throat bones, and viscera, there is little left for determining family, much less genus and species.) None of these keys will be repeated in later parts.

Not included in this volume, because contributions were not forthcoming, were families Alepocephalidae and Searsiidae. There is a vague promise that they may appear in a future part.

As in Parts 1 and 2, there is a wealth of information on life histories, abundance, importance to man, enemies, predators, distribution, etc. These accounts are easy to read and to understand, even for a fisherman with little or no technical background, which is, I am sure, a reflection of the long hours put in by competent editors.

Typographical errors are difficult but not impossible to find. On page 115, tarpon are said to be "3,050 - 3,060 mm in length at one year," and in the *Anchoviella* synonyms on page 199 is "*epsetus*" for "*hepsetus.*"

Even though the price of this volume ($27.50) is a real shocker, I heartily recommend its purchase. Ichthyologists and fishery biologists can ill afford to do without the series, and I suspect fishermen and "booklovers" will want it too. Many of today's "solid" stocks and bonds are poorer investment risks than a set of *Fishes of the Western North Atlantic.*—*John E. Fitch, California Department of Fish and Game.*

The Genera of Fishes and a Classification of Fishes

By David Starr Jordan, Stanford Univ. Press, Stanford, Cal., reprinted 1963; xvi + 800 pages; $17.50.

Stanford University Press should be congratulated for making these classic compilations again available to a new generation of ichthyologists. The original five separate parts have been combined into one volume; however, each part retains its identity within this volume. The original separate indexes have been omitted from this facsimile reprint, but have been combined with an alphabetical index developed and used at the United States National Museum and printed here for the first time. There is one alphabetical index to the genera contained in this volume. Index B., "Names of Families and Higher Groups," has been reprinted from the *Classification*.

In the "Foreword," George S. Myers provides words of counsel on using this volume. He also voices the only possible criticism of this book with: "It is unfortunate that a completely revised, up-to-date edition of Jordan's work, embodying the corrections of a group of ichthyologists, could not be issued. However, no one has been found with both the ability and time to carry through such an extensive revision."

The universal use of these works and the demand that has existed for both the *Genera* and the *Classification*, long out of print, certainly justify their reprinting. This book should be available to all fishery workers and ichthyologists, and its initial price will be repaid many times over in time saved on research in zoological nomenclature.—*E. A. Best, California Department of Fish and Game.*

Vegetation and Soils, a World Picture

By S. R. Eyre, Aldine Publ. Co., Chicago, 1963; xvi + 324 pp., illustrated; $7.95.

This book takes a wide brush to the general subject of vegetation and soils, stressing key ecological concepts. It begins with several general chapters on the development of plant communities and soil profiles. In the rest of the book, "the treatment adopted is a regional one; the land areas of the earth are sub-divided according to the distribution of the main vegetation types upon them and the vegetation and the soil of each region are viewed together," to quote the author's preface. There are ten vegetation maps of the world.

The book is intended primarily for college students in geography and related fields. Budding biologists interested in human ecology will enjoy it and so will many of their more mature colleagues. Man's impact upon soils and vegetation receives special attention.—*Alex Calhoun, California Department of Fish and Game.*

All Creatures Great and Small

By Daniel P. Mannix, McGraw-Hill Book Co., New York, 1963; viii + 241 p., illustrated; $5.95.

This book is both entertaining and informative. The author brings to the reader small portions of his experience in raising and keeping wild animal pets, from his first skunks to the world famous Aguila, the golden eagle.

Mannix begins with his early childhood and his first experiences with wild animals and in reading the hilarious account of his first skunk encounter, the reader is captured by his warmth and humor. From these childhood adventures the author goes on to tell how wild animals became his life and livelihood. His writing shows an understanding and insight into the behavior, both "physical and Psychological" of the animal kingdom.

The book is light reading, not technical in any sense, and should be enjoyed by anyone who has an interest in animals.—*Hugh L. Thomas, California Department of Fish and Game.*

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